LEARNING AND RETENTION

A Comparison of Three Experimental Procedures

BY
ANNETTE L. GILLETTE, PH.D.

ARCHIVES OF PSYCHOLOGY
R. S. WOODWORTH, EDITOR
No. 198

NEW YORK
April, 1936

ARCHIVES OF PSYCHOLOGY

COLUMBIA UNIVERSITY, NEW YORK CITY

The Subscription price is six dollars per volume of about 500 pages. Volume I comprises Nos. 2–10; Volume II, Nos. 11–18; Volume III, Nos. 19–25; Volume IV, Nos. 26–32; Volume V, Nos. 33–39; Volume VI, Nos. 40–46; Volume VII, Nos. 47–52; Volume VIII, Nos. 53–58; Volume

(Continued on inside back cover.)

LEARNING AND RETENTION

A Comparison of Three Experimental Procedures

BY
ANNETTE L. GILLETTE, PH.D.

ARCHIVES OF PSYCHOLOGY
R. S. WOODWORTH, EDITOR
No. 198

NEW YORK
April, 1936

ACKNOWLEDGEMENT

This study was conducted under the direction of Professor H. E. Garrett, Department of Psychology, Columbia University. Subjects for the experiments were obtained through the cooperation of Dr. A. Anastasi and Dr. G. H. Seward of Barnard College; Mr. G. A. Schiavone, Superintendent of Union Free School, District No. 7, Poughkeepsie, New York, and Mr. H. C. Storm, Principal of Arlington and Pleasant Valley Grade Schools.

CONTENTS

CHAPTER I

THE PROBLEM AND ITS HISTORY

1. *Problem*

This study is an investigation of the old question of whether the fast learner is the better retainer or whether the saying "Easy come, easy go," more nearly describes the relation of speed of learning to retentivity.

The specific problem considered here is the relation between the *learning* of visually presented paired associates and the *retention* for a definite interval of time of those pairs which have been learned completely. In the measurement of speed of learning two factors are involved, *time* to learn the material, and *amount* of material learned. Either one of these factors may be held constant while the other varies. Hence there are two methods which have ordinarily been used in attacking this problem. In the first method, all subjects are allowed to learn the material *completely,* the speed of learning being determined by the *time* necessary to learn. In the second method, equal opportunity is given for all subjects to learn the material, and speed of learning is measured by the *amount* of material learned in a constant time. In this investigation both of these methods have been followed with certain improvements in experimental and statistical procedure. In addition, a third method has been employed which avoids, in part at least, the difficulties inherent in the others. All three of these methods, and the results from previous experiments employing them, will be considered briefly.

2. *The Method of Equal Amount Learned*

In the method of Equal Amount Learned, the time to learn the material is the variable and the amount of material learned is the same for all subjects. This method sets up conditions which favor the slow learner[1] in recall. When the material is learned completely, there is always an opportunity for overlearning of those parts which are learned first. For instance, in the case of paired

[1] The terms fast, average and slow learners refer to groups the limits of which are determined by the standard deviation of the distribution of learning scores. "Slow learners" are those subjects whose scores range from the mean -1σ to -3σ; "average learners" have scores between the limits of the mean $\pm 1\sigma$; "fast learners" have scores from the mean $+1\sigma$ to $+3\sigma$.

associates, the response to one stimulus may be given by the subject on the first trial. Since this pair is seen again on each successive trial, there is an opportunity for it to be learned more and more completely. However, the pairs learned on the last trial are not seen again; and so although they may be learned to the point where a correct response can be given, there is no opportunity for more thorough learning. Overlearning differs with the subjects, but usually occurs more frequently in the slow learners. The fast learner is at a disadvantage when tested for recall since he has seen fewer exposures of the material.

The relevant results from earlier studies with the method of Equal Amount Learned are summarized in Table I. A criticism which may be made of the studies of Radossawljewitsch (Table I, 5), Lyon (Table I, 8), Myers (Table I, 9) and Henmon (Table I, 10) is that overlearning of the entire selection was not prevented. Instead of testing the subjects at regular intervals, they gave a test only when the subject considered the material completely mastered. Undoubtedly, some subjects were more cautious than others and learned the material more thoroughly before being tested. The number of subjects is very small in the studies by Ebbinghaus (Table I, 1), Ogden (Table I, 4), Radossawljewitsch (Table I, 5), Henmon (Table I, 10), and Luh (Table I, 13).

Experimenters using the method of Equal Amount Learned may be more conveniently considered in two groups: those who measured the *units recalled* after the interval without any relearning and those who measured retention by *relearning only*. Correlations of either measure with learning scores are influenced by the experimental condition of overlearning described above.

When *units recalled* after the interval were considered in relation to learning scores, Pyle (Table I, 7) found that the slow learner has no advantage and Lyon (Table I, 8) that the fast learner was definitely better in retention. Correlations by Lyon (Table I, 8) and Luh (Table I, 13) show a tendency for fast learning to be associated with a large number of units retained. The overlearning of the slow learner which has been discussed, lead us to expect the opposite; but results from these three earlier investigations Pyle (Table I, 7), Lyon (Table I, 8), and Luh (Table I, 13) which considered *recall* scores, show that the fast learner is the better retainer in spite of his disadvantage.

The investigators who considered only the *relearning* scores and the *per cent* saved, Ebbinghaus (Table I, 1), Muller and Schuman

TABLE I

SUMMARY OF PREVIOUS EXPERIMENTS USING THE METHOD OF EQUAL AMOUNT LEARNED

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
1. Ebbinghaus from Lyon (14) 1885	1 adult	Nonsense syllables. Stanzas of Don Juan	Read by subject until learned. Recitation between each reading	Relearn	24 hours	*Number of readings to learn* / *relearn* / *% saved in relearning* 12 syllables 16.5 11.0 33 24 syllables 44.0 22.5 49 36 syllables 54.0 23.0 58 Stanza 7.75 3.75 52
2. Muller and Schuman from Lyon (14) 1887		Nonsense syllables	Read from revolving drum	Relearn	24 hours	Quick learner relearns quickly Slow learner saved more time relatively and absolutely
3. Whitehead (33) 1896	13	Nonsense syllables	Visual presentations on rotating drum. Also auditory presentation	Relearn	1 week	Greater number of original repetitions the less the number needed for relearning Whitehead's figures do not support this statement
4. Ogden (21) 1904	3	Logical and nonsense syllables	Syllables presented one at a time. 12 syllables in each list presented at different rates	Relearn	14 days	Slow learner always needs as much time to relearn as fast learner and relatively much more

TABLE I

(*Continued*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
5. Radossawljewitsch from Drake (3) 1907	12 adults	8, 12, and 16 nonsense syllables	Material read by subject until learned to criterion of 2 errorless repetitions	Relearn		*Nonsense syllables*: *8* / *12* / *16*; *Poetry*
					24 hours	.46–.04 / .35–.02 / .53–.14 / .88–.05
					48 hours	.44–.04 / .37–.03 / .65–.11 / .72–.10
					72 hours	.14–.04 / .41–.03 / .52–.14 / .52–.15
	11 adults	Poetry			96 hours	.08–.07 / .34–.03 / –.23–.09 / –.69–.11
					120 hours	.25–.07 / –.70–.10 / –.72–.10
						(rank difference correlations and probable errors)
6. Busemann from Lyon (14) 1911	Children 12–18 years	Words	Complete memorization Method of right associates	Relearn		Slow learner requires less time relatively to relearn Probably good learner is good retainer
7. Pyle (24) 1911	I 4	Nature study passage	Individual experiment. Alternate reading and oral recall until 40 ideas correctly recalled. Three methods used; read aloud by subject, read aloud by experimenter, read silently by subject	Recall	24 hours	*Subject* / *No. repetitions to learn* / *Amount retained* B 3.66 40 M 6.33 37 Th 10.33 34 Wi 6.33 40
	II 4	Nature study passage	Four experiments with each type of presentation named above	Recall	24 hours	*Averages of different methods* *Subj.* / *Repetitions to learn* / *% variations* / *Retention* / *% var.* Tr 7.5 28 33.92 7 St 4.42 16 33.83 8 Sc 6.17 14 36.17 4 Ti 3.17 18 38.42 3 Conclusion: Fast learner is at no disadvantage in retention

TABLE I

(*Continued*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
7. Pyle (24) 1911	III 4	Nature study passage	Material read to subject	Reproduce in writing	24 hrs.	*Subject* / *Repetitions to learn* / *A.D.* / *Retention* / *A.D.* C 4.7 2.24 37.5 2.0 F 2.9 0.78 38.5 1.7 K 5.2 1.40 34.2 4.6 J 3.6 1.90 36.7 3.2 Conclusions: Slow learner has no advantage over fast learner
8. Lyon (14) 1916	12 groups number in each ranges from 12 to 132	Digits Nonsense syllables Words Prose Poetry	Subject studied material any way he desired until he felt certain he could repeat it without error. If error made in recitation subject returned for further study but seldom occurred as deductions made for minor errors.	Method 1 recall Method 2 recall after 1 presentation Method 3 relearning	Digits and nonsense syllables 3 days or 1 week; Words, prose and poetry, 3–10 weeks	Correlations summarized but not given in actual figures; *Method 1*—positive correlation indicating quickness of learning with large amount retained. *Method 2*—similar to Method 1. *Method 3*—quick learner tends to retain less. Conclusions: Relation of quickness of learning to retentiveness depends on method used for retention. Quick learner remembers longest if material logical, converse true if material not logical. Considering the three methods and all material, except for digits, those who learn quickest, forget the least.
9. Myers (19) 1916	50 Normal School girls	Words and figures	Subject to study group of words and figures so able to reproduce. No limit on time	Recall	Immediate	Correlation of learning time and recall time $-.380 \pm .0816$

TABLE I

(*Continued*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
10. Henmon (11) 1917	3 adults	Poetry	Memorize by whole method, five stanzas learned at one sitting	Relearn	24 hrs.	*Subjects* / *No. trials learn* / *M.V.* / *No. trials relearn* / *M.V.* / *Economy* *1 stanza* H (10 exp.) 3.3 0.6 1.3 0.4 61 D (10 exp.) 3.5 0.7 1.1 0.4 69 P (5 exp.) 3.8 0.6 2.0 0.4 47 *5 stanzas* H 8.6 1.2 2.6 0.6 69 D 14.0 1.8 2.3 1.6 80 P 14.0 2.8 4.6 0.7 67
11. Vlaïcou (32) 1920	56 boys 56 girls	Table of 16 numbers in 4 lines	Table presented visually and read aloud by subject. Recited as much as possible, then read again. Continued until completely learned.	Recall and relearn	8 days	*Correlation of learning score and per cent saved in relearning* *Boys* / *Girls* / *Average* Spearman −.287 −.336 −.3115 Pearson −.279 −.221 −.250 (Vlaïcou gives Pearson formula but calls it Spearman's)
12. Smith and McDougall (26) 1920	2 adults	List of 10 nonsense syllables	Syllables exposed one at a time on rotating drum. Learned completely. Different attitudes in learning.	Relearn	24 hrs. 7–18 days	*Number of trials* *Subject 1* / *Subject 2* *Active Attitude* / *Passive Attitude* / *Active Attitude* / *Passive Attitude* *L.* *R.* *L.* *R.* *L.* *R.* *L.* *R.* 10 6 41 4 7.5 4 40 9 10 6 90 5 8 5.6 172 7.5 *L.* = Learn *R.* = Relearn

TABLE I

(*Concluded*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Results*					
					20 m.	*1 hr.*	*3 hr.*	*4 hr.*	*1 da.*	*2 da.*
13. Luh (13) 1922	2 groups of 10 subjects	Nonsense syllables 12 in series	Learned by anticipation method visual presentation	Relearning (% saved)		−.42 ± .18			−.42 ± .18	
				Relearning (speed)	.50 ± .17	.21 ± .21		.98 ± .01	.35 ± .20	.78 ± .09
				Anticipation (recall)						.51 ± .18
				Reproduction when 150% learned			.43 ± .18			
				100% learned	.30 ± .15	.40 ± .14				
				67% learned	.40 ± .19					
				33% learned					.50 ± .17	
					Rank difference r. Negative r in Relearning (% saved) due to method.					
					Conclusion: With recognition method correlation of speed of learning and amount retained tends to change from positive to negative as interval longer. With written reproduction method correlation between speed of learning and amount retained is positive if any. The fastest learners are as a rule the best retainers.					

(Table I, 2), Whitehead (Table I, 3), Ogden (Table I, 4), Radossawljewitsch (Table I, 5), Busemann (Table I, 6), Henmon (Table I, 10), Vlaïcou (Table I, 11), Smith and McDougall (Table I, 12) conclude that the fast learner relearns more rapidly than the slow learner, but does not save as great a per cent in relearning. Whitehead (Table I, 3) is the only one who concludes that the slow learner needs fewer repetitions to relearn but his figures do not substantiate his conclusion.

Correlations between learning and relearning are influenced by two experimental conditions. First, overlearning would make it possible for the slow learner to relearn more rapidly than he learned, hence a large per cent saved would tend to go with slow learning. But there is another fact to be considered. A subject who is a fast learner probably would relearn rapidly anyway. Hence a positive correlation between number of trials to learn and number of trials to relearn may not be the result of good retention by the fast learner, but rather of rapid relearning.

Instead of correlating speed of learning and retention, the subjects may be divided according to learning ability, and the retention of fast, average and slow learners compared as Lyon (Table I, 8) does. In such comparisons, however, we should not employ original scores as raw scores do not fall along a scale of equal units. Hence direct comparison of losses by different groups and at different stages of learning cannot be fairly made. Sigma scores avoid at least the error of unequal steps in difficulty, though they do not avoid the other difficulties mentioned.

3. *Method of Equal Opportunity to Learn*

The method of Equal Opportunity to Learn holds the time for learning constant for all subjects, while the amount of material learned in that time varies with the ability of the subject. In a fixed time, the fast learner learns more than the slow and so has a chance to recall more. The slow learner can recall only a small amount, as he learned only a small amount. Hence, when retention of the material is tested after a given interval (in order to measure delayed memory) the retention score in absolute units will favor the fast learner in the methods usually employed. However, this is not true of Norsworthy's procedure (Table II, 4).

The details of the procedure and results from earlier relevant studies which employed this method are given in Table II. Most of these studies have measured the relation between the factors in-

vestigated by means of correlation. In the studies by Thorndike (Table II, 2 and 3), Norsworthy (Table II, 4), Boswell and Foster (Table II, 6), J. Peterson (Table II, 7), Gates (Table II, 8), and Brown (Table II, 9), in which disconnected material was employed, the correlations are positive and quite high except in two cases. Boswell and Foster (Table II, 6) obtained a negative correlation when the attitude of the subject was for temporary retention; but no relation was shown when the attitude was for permanent retention. However, the results of this study cannot be applied very generally as they were based upon the records of only a few subjects. The correlations calculated from J. Peterson's data (Table II, 7) for passive attitude are also low. In the studies by Henderson (Table II, 1) and Gates (Table II, 8) where the *proportion* retained of the material originally learned (instead of absolute score) is correlated against the number of items learned, the results are lower but still positive.

With connected material, Henderson (Table II, 1), Pyle (Table II, 5), Gates (Table II, 8), Gordon (Table II, 10), H. A. Peterson (Table II, 11), obtained correlations which are all positive and high. When proportion retained or per cent retained is correlated against number of items learned, the correlations are positive, but lower than corresponding correlations for absolute scores.

The conclusion reached by these earlier workers is that the fast learner is the better retainer. This finding may be an artifact since the experimental set-up of the method of Equal Opportunity is such that correlation hardly gives an accurate picture. The reason for this is the advantage already considered (page 12) that the fast learner has in retention. Because of this advantage the correlation between absolute scores would tend to be positive. Previous studies bear this out quite consistently.

There is another objection to the use of correlation between learning and retention scores. This is the inaccuracy due to errors of measurement. Thorndike (31) and Syrkin (28) have shown that when *initial scores* are correlated against *gain,* the correlations are more *negative* than would be the case if the measures used were free of chance error. Thorndike (31) demonstrated this by setting up hypothetical data in which there was no correlation between original score and gain. Applying random errors, he obtained a negative correlation between original scores and gain, although there had been no correlation in the "true" scores. When

TABLE II

SUMMARY OF PREVIOUS EXPERIMENTS USING THE METHOD OF EQUAL OPPORTUNITY TO LEARN

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
1. Henderson (10) 1903	156 children 21 college students 18 graduate students 17 summer session students 212	Five prose passages	Read passage through twice then memorized as desired. Time limit 3 minutes. Written reproduction immediately of ideas in exact words if possible	Written reproduction in exact words as far as possible	4 weeks 2 days	Correlations of immediate reproduction with reproduction after intervals Score in ideas: *2 days* *4 weeks* 1st passage ..... .96 ± .003 .88 ± .01 2nd passage ..... .87 ± .014 .75 ± .026 Per cent loss in ideas ..... .16 ± .059 .19 ± .059 General conclusion: Those who learn quickest retain greater per cent of that learned
2. Thorndike (29) 1908	22 adults	German-English vocabulary	Given list as paired associates, 10 pairs in each list. 10 lists to be studied in 1 hour. After 6 days with different lists restudied lists. Each set studied 5 times. Immediately after studying wrote English equivalent to German word	Tested on 120 words at different intervals	37 days	Rank difference correlation of .40 Concluded quick learner is good retainer

TABLE II

(*Continued*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
3. Thorndike (30) 1910	40 adults	5 lists of 12 words each	List read to subject once at rate of 1 word per second. Subject scored own list	Recall of as many as possible of 60 words	24 hrs.	Correlation of number of words recalled immediately and after interval .55 ± .1 (raw) .80 ± .1 (estimated true)
4. Norsworthy (20) 1912	83 students of educational psychology	German-English vocabulary	Studied for 20 min. a day for 5 days learning 40 words or more each day. Rested 2 days and reviewed words learned in 5 days. Rested 2 days and again reviewed words	Tested at next meeting of class on 50 words selected from the list of 200 words studied by all subjects Tested on another 50 after interval	First test 2 days Second test 1 month	Correlation of number learned with per cent recalled on tests First test .41 Second test .50 Grouped by number of words learned in time given — Average per cent recalled: *1st test* / *2nd test* First half of class ..... 70 / 73 Second half of class ..... 52 / 47 Divided in nine groups: First group ..... 76 / 78 Ninth group ..... 46 / 36
5. Pyle (25) 1913	600 children (2 groups)	Prose passage from Whipple test "Marble Statue"	Passage read aloud once by experimenter	Recall	5 wks.	Correlation of number of items recalled immediately and after interval First group ..... .76 ± .02 Second group ..... .70 ± .03

TABLE II

(*Continued*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
6. Boswell and Foster (1) 1916	4 adults	Chinese-English vocabulary 8 series, 16 pairs each	Pairs exposed for 2.5 seconds each for 16 continuous repetitions. Two series learned each day, 1 for permanent and 1 for temporary retention.	Recall English equivalent of Chinese	2 weeks	*Subject* — *Permanent* Immed. 2 wks. — *Temporary* Immed. 2 wks. E ..... 61 20 59 22 W ..... 53 7 61 9 D ..... 47 21 52 18 L ..... 58 48 59 41 Rank difference correlation calculated using above data— Permanent 0 Temporary – .25
7. Peterson, J. (23) 1916	Two Groups 1. 12 2. 29	Two lists of 20 words each	List copied by students 1 list with intent to learn, other without.	Recall lists	2 days	*Active* — *Passive* Group 1 ..... .68 ± .10 .29 ± .18 Group 2 ..... .66 ± .07 .23 ± .12 Correlations calculated from data given by Peterson.
8. Gates (5) 1918	299 (3–8 grade)	Nonsense syllables	Time limit of 9 minutes. Whole method to be used	Recall	3 or 4 hours	*Immediate recall correlated with* *Grade* — *Amount Recalled* — *Proportion* 8(4 hrs) ..... .73 ± .04 .41 ± .09 6(3 hrs) ..... .78 ± .04 .35 ± .09 4(3 hrs) ..... .73 ± .05 .42 ± .09
	299 (3–8 grade)	Biographies	Same as above	Recall	3 or 4 hours	8(4 hrs) ..... .81 ± .04 .46 ± .08 6(3 hrs) ..... .86 ± .03 .42 ± .09 5(3 hrs) ..... .79 ± .04 .28 ± .10 4(4 hrs) ..... .89 ± .03 .51 ± .08 3(3 hrs) ..... .80 ± .04 .40 ± .09

TABLE II

(*Continued*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
9. Brown (2) 1924	531	48 words	Each word read aloud and a brief phrase using the word. List read as a whole 1. Written recall immediately	2. Recall after short interval with learning of nonsense syllables during interval 3. Recall after longer interval	8 or 16 minutes 3–7 days	*Short interval* — *Average correlations* Interval of 8 min. ..... r_{12} .86 r_{13} .74 " " 16 min. ..... r_{12} .83 r_{13} .64 Grouped according to longer interval: *Days* 3 4 5 6 7 r_{13} .74 .70 .63 .68 .65 r_{23} .83 .82 .78 .72 .71
10. Gordon (8) 1925	College Students Group I 101 Group II 74 Group III 40 Group IV 82	Athenian Oath	Experiment to show the effect of spaced and unspaced learning: I Read by experimenter six times in succession in one day; II Read 3 times 3 day interval, read 3 times; III Read 3 times in one day; IV Read 3 times with interval of one week between each	Recall when readings completed Recall after longer interval	Groups I & II 4 weeks Groups III & IV 3 weeks	Correlation of number of items recalled immediately after readings completed and after longer interval *Group* I ..... .42 II ..... .70 III ..... .52 IV ..... .71

TABLE II

(*Concluded*)

Experimenter	*Subjects*	*Material*	*Method of Learning*	*Retention*	*Interval*	*Results*
11. Peterson, H. A. (22) 1925	56 Normal School student	Geographical selection on Philippines	To study 2½ min. Reproduce as much as possible in own language immediately	Recall	1 week	*Quartile* — *Avg. learning score* — *Avg. retain score* — *% retained*: 1: 25.5, 22.2, 88; 2: 19.1, 15.3, 80; 3: 14.9, 12.7, 85; 4: 9.1, 7.9, 88. r = .87 ± .02 (number of units)
	Same	Selection on policies of Labor Union	Determined own length of time but told it would count in score. Answered questions	Answer questions	1 week	*Avg. score in percent*: *L.*, *R.*; *Avg. L. time*; *Avg. score per min. L. time*: *%L.*, *%R.*, *Avg. R.%*. Quart. 1: 74, 68, 9.5, 7.8, 7.1, 91; 2: 57, 47, 10.5, 5.4, 4.5, 83; 3: 40, 37, 12.2, 3.3, 3.1, 94; 4: 21, 20, 12.9, 1.6, 1.5, 94. *r* = .94 ± .01 (% score). *L.*—Learning *R.*—Retention
12. Stump (27) 1927	16 high school seniors taking civics	Civics material outlined as series of problems and items for solution	Class discussion of outline for half hour then questions asked on principles discussed. Second day, discussed first principles again. Third day progressed to next principle as one student answered questions on first correctly. Other students did not answer questions on second principle until first completed	Scored on answers each day. Retested at intervals	14 days 28 days 42 days	Rank difference correlations of cumulative scores and index of retention. r = .71 ± .087. Comparison of two extreme subjects. *Rapid* — *Slow*: Number of items learned in 20 days: 500, 200; % retained 14 days: 93, 64; % retained 28 days: 100, 50; % retained 42 days: 98, 43

the correlation is between *initial score* and *loss,* errors of measurement would tend to make the correlations more *positive* than the "true" relation. The reason for this can be more clearly seen from the following formulas:

Correlation between *initial score* and *loss*

$$r_{A(A-B)} = \frac{\sigma_A - r_{AB}\,\sigma_B}{\sigma_{(A-B)}}$$

A = initial score
B = final score

Correlation between *initial score* and *gain*[2]

$$r_{A(B-A)} = \frac{r_{AB} \cdot \sigma_B - \sigma_A}{\sigma_{(B-A)}}$$

A–B = loss (final score less than initial score)
B–A = gain (final score more than initial score)
r_{AB} = reliability coefficient

When the correlation is between *initial score* and *loss* and the reliability coefficient is small, the product $r_{AB}\,\sigma_B$ will be small and the numerator large. The correlation is then more *positive* than it would be were r_{AB} larger and the test more reliable. For the correlation between *initial score* and *gain,* a low reliability reduces the numerator, and may make it negative; hence the correlation is more *negative* than it would be with more reliable measures.

Because of correlational difficulties the method of dividing the group into fast, average and slow learners and comparing the average retention scores of these groups is often employed. The use of original scores for this may be criticized (page 12) on the ground that the units of the scale are probably unequal. Scaling the data in sigma units permits comparison of losses, since the absolute losses being measured in equal units are at least comparable. But sigma-scaling does not eliminate the difficulty arising from the fact that subjects reach different points in their learning, so that retention must be measured from different bases.

4. *Method of Adjusted Learning*

Another method of presenting the material, used by Woodworth (34), may be called the method of Adjusted Learning. By this method the retention of pairs of words learned on different trials by the same subject was studied. Woodworth found that those pairs learned first by an individual were the ones most often retained over a period of time. He concluded from this that quick learning in an individual tends to favor retention.

---

[2] Hartshorne and May (9).

Woodworth's procedure was to read pairs of Italian words and their English equivalents to the subject, one pair at a time. The subject was tested immediately after presentation to determine how many pairs had been learned on the first trial. All Italian words, to which the correct response was given, were removed from the series. The remaining pairs were then read and the subject tested immediately. Again the pairs to which the correct responses had been given were removed. Presentation trials and test trials alternated until all the pairs had been learned but by this method a pair to which the response was correct was not read on any succeeding trial. In this way all the subjects completely learned the material or learned it at least up to the same point, without having an opportunity to overlearn any of the pairs. The chief disadvantage of this method is that when most of the pairs have been learned, only two or three are left for presentation. These are tested immediately, and probably recalled because they were so recently presented; but they might not be as thoroughly learned as the others. This difficulty might be avoided by having a given number, rather than the complete list, learned by all of the subjects. With this modification, Woodworth's method seems to avoid the difficulties inherent in the other methods described. We have employed it, therefore, to check the results obtained by the other two methods.

5. *Plan of Present Study*

Realizing the difficulties inherent in the two methods, Equal Amount Learned and Equal Opportunity to Learn, we have employed both methods with similar material and procedure in the hope that one might substantiate the other. In addition, we have further checked our findings by the method of Adjusted Learning.

If the three methods agree, it may be considered conclusive evidence for the relationship indicated by the results. However, since the experimental conditions of the methods of Equal Amount Learned and Equal Opportunity favor the slow and fast learners, respectively, we shall expect results indicating better retention in the group favored, provided there is no initial difference in the memory capacity of the two groups. To obtain agreement of these two methods, then, the results from one of them must be contrary to expectation. Such an outcome would be strong evidence for the relation indicated since the phenomenon would be manifesting itself in spite of the experimental conditions against it.

CHAPTER II

THE METHOD OF EQUAL AMOUNT LEARNED

1. *The Method*

In the method of Equal Amount Learned the subjects were allowed to learn all the material to the point of one perfect repetition. The time for learning the material varied according to the ability of the subject, giving a measure of speed of learning. The measures of retention employed were (1) the number of *items retained* (i.e., items recalled) after the five day interval, and (2) the number of *trials to relearn* the material after five days.

This experiment is very similar to those carried out by previous workers (pages 7 to 11) with slight changes in method. It is included here, in spite of its disadvantages, for comparison with the other two methods discussed in later chapters.

2. *The Subjects*

The subjects for this experiment were Barnard College students who were taking the two laboratory courses in psychology; and a few students from other psychology classes who volunteered to be subjects. Complete records were obtained from 54 students. The experiment was carried out during the regular laboratory periods for the two classes, and the other students came at scheduled times. Procedure and conditions were similar throughout, and the same experimenter served for all groups. As no statistically reliable differences were found between the learning or retention of the different groups, all results were combined and the entire 54 cases treated as one group.

3. *Materials*

The material to be learned consisted of paired associates in which one member of the pair was something that could be written easily. Paired associates were selected as this material is better adapted for testing the progress of learning than is a continuous list. Discrete stimuli to which the subject is to respond are provided so that scoring of partially correct lists is avoided.

Presentation material was mounted on cards made of heavy white cardboard of sufficient size to allow wide margins and good spacing for the material. The letters and numbers used were two inches in

height cut from black paper. (Willson's gummed letters). Three types of stimulus pairs were selected in order to obtain a range of material and to allow comparisons. They were as follows:

1. Word-word pairs: four letter English words with no obvious association between a pair. Examples are: busy-plum; lamp-rule. There were fifteen pairs in the series.

2. Form-number pairs: simple black line geometrical figures approximately three inches square and two-place numbers. Examples are: outline cube—97; square with circle overlapping one corner—89. This series consisted of ten pairs.

3. Color-letter pairs: three inch square each half of which was a different color and a meaningless two letter combination. Examples are: red and black—SG; orange and brown—HQ. The colors were cut from Dennison's gummed papers as far as possible but other kinds of paper were used to get sufficient variety. The colors selected were red, orange, green, blue, violet, purple, brown, black, pink, grey. There were ten pairs in the series.

The number of pairs in each series was determined after a preliminary experiment on a few subjects. The original plan was to have longer series but it was not practical in the time at our disposal.

4. *Procedure*

Subjects were requested not to discuss the material or review it during the interval between learning and recall. They were also told that their retention would be tested at a later time. It was hoped that this information would create a more uniform attitude, since it has been found (1 and 23) that retention differs if the attitude at the time of learning is for permanent rather than for temporary retention.

The word-word series of paired associates was learned first. Each pair was shown to the subjects by the experimenter for three seconds, the time being regulated by a metronome set at 60. After the series had been presented, the cards were shown so only one word was seen, the other being concealed by a cover card. Response words were written by the subject on the mimeographed sheet provided, five seconds being allowed for each response. In this way progress of learning was tested and the first trial on which all responses were given correctly was determined. Presentation trials were alternated with test trials until everyone in the group had completed the learning of the series. The score was the number of

presentation trials necessary to learn the material to the point where all the responses on one trial were correct.

After each trial the subjects who had completely learned the series were asked to leave the room. Completion of learning was determined by checking the papers of all subjects who had made a response to each stimulus on that trial. Each subject checked her own paper against a key of the responses in the order in which they should appear on the test paper. In order to decrease the possibility of learning during the checking, only the response member of each pair was given in the key. A possible source of error lay in the fact that in some cases the learning time of a subject may have been shortened by the fact that she corrected her own paper.

Checking the responses against a key necessitated a previously determined order of the cards. The arrangement of the series was different for each trial so that no pair had the continued advantage of primacy or recency. The changing order also made it impossible for any subject to learn the responses as a list rather than as members of pairs.

Since each subject learned the material to one perfect repetition and then withdrew, there was no overlearning of the complete list. This procedure did not, however, eliminate the probability of overlearning the pairs first learned.

After the word-word series had been learned by all the subjects, the form-number series was learned by the same procedure; and following this the color-letter series was learned. The time required by a group to learn the three series was about an hour and a half.

Five days later the material was relearned. The first trial at this time was a test trial to determine how many correct responses could be recalled without any relearning. The material was then learned to the point of one perfect repetition, the procedure being similar to that in the learning period. The word-word series, the form-number series and the color-letter series were taken in order. The time necessary for the second part of the experiment was about three quarters of an hour.

5. *Results*

Three measures of memory were taken: (1) the number of trials necessary to *learn* each series to the point of one perfect repetition; (2) the number of *correct responses recalled* after the interval of five days without any relearning; (3) the number of trials required to *relearn* the material to one perfect repetition after five days.

a. *Analysis by correlations.*—The most frequently used statistical device for determining the relation between two variables is the coefficient of correlation. The results obtained from correlations in this study are shown in Table III.

TABLE III

METHOD OF EQUAL AMOUNT LEARNED
Correlation of number of trials to learn and retention scores after five days
Retention measured by number of pairs retained and number of trials to relearn. Correlations are between raw scores
N = 54 Barnard College students

Material	*Number of Trials to Learn Correlated VS*	
	(*1*) *Number of Pairs Retained After Five Days*	(*2*) *Number of Trials to Relearn After Five Days*
Word-word	−.02 ± .09	.36 ± .08
Form-number	.08 ± .09	.15 ± .09
Color-letter	−.13 ± .09	.21 ± .09

First, there are the correlations between *number of trials to learn* and *number of pairs retained* (i.e., number of pairs recalled). If *slow* learners are better retainers than fast learners, we should expect, other things being equal, to find a high *positive* correlation between *number of trials to learn* and *number of pairs retained.* Contrariwise, if *fast* learners are the better retainers, we should expect a decided *negative* correlation between these two variables. However, the condition of overlearning, inherent in the experimental method, works against a clear-cut result. If the slow learner has superior ability to retain, overlearning should increase the already positive correlation between number of trials to learn and number of pairs retained. But if the fast learner is the better retainer, overlearning (by the slow learner) should decrease the already negative correlation between the two variables, bringing it to zero or to a small positive value.

The correlation between number of trials to learn and number of pairs retained found in this experiment are given in Table III, column 1. These correlations are negative, small and unreliable. It seems reasonable to assume that overlearning, working against the fast learner, was not strong enough to produce positive correlations except in the form-number material; but was sufficiently strong to cut down the significant negative correlation which would have

given us a clear-cut result. Hence, the evidence, though decidedly meager, is in favor of the thesis that the fast learner is the better retainer.

The correlation between *number of trials to learn* and *number of trials to relearn* is shown in Table III, column 2. If the *slow* learner is the *better retainer,* the correlation here should be *negative* (many trials to learn, few to relearn). But if the *fast* learner is the *better retainer,* the correlation should be *positive* (few trials to learn, few to relearn). Neither of these two opposed results comes out clearly in our data. The first difficulty seems to be that the fast learner, without actually having better retention, may simply relearn faster than the slow, just as she learned faster originally; this influence would make for positive correlation. The second difficulty arises from the fact that overlearning may cause the slow learner to relearn more readily than she would were this factor absent; this makes for negative correlation. Thus these two influences operate at cross purposes, the first making for positive correlation and the second for negative correlation; the first working for the fast learner, the second for the slow.

The correlations in Table III, column 2, are positive, but reliable only for the word-word series. The fact that they are at least positive offers evidence in favor of the fast learner as the better retainer, but unfortunately, this evidence is not conclusive.

b. *Analysis by comparison of groups differing in learning ability in terms of number of pairs lost in the five day interval.*—Since correlations are difficult to interpret because of complicating conditions inherent in the experimental set-up, another method of analysis was employed. The entire group was divided into subgroups according to initial ability in learning the material. Divisions were based on the average of the group and the standard deviation of the distribution for each type of material. Average learners were taken to be those whose scores lay between the points $\pm$ one sigma from the mean of the group; fast learners were taken to be those whose scores lay between + 1 sigma and + 3 sigma; slow learners were those whose scores lay between − 1 sigma and − 3 sigma. These divisions give us three groups within which the range of ability is equal, each covering two sigma of the distribution. Retention scores for each group were computed in the following terms: (1) average number of pairs lost (i.e., forgotten) in the five day interval; (2) the per cent of pairs lost in the five day interval; (3) average number of trials to relearn. The differences between the groups in all these measures

were then compared and the significance of the differences determined statistically.

Sigma scales were constructed for learning scores and for number of pairs recalled so that differences in retention could be compared on a scale of equal units. In transmuting the original scores into sigma scores, the mean was set at 50 and the S.D. set equal to 10. The group was subdivided on the basis of learning scores in sigma units and retention in sigma units compared.

Results in terms of the number of pairs lost (i.e., forgotten) during the five day interval are shown in Table IV for original scores and Table V for sigma-scaled scores. More pairs are lost proportionally in the form-number and color-letter series, showing that those pairs which have no meaning are harder to retain. When the percentage of pairs lost in the interval is considered, the fast learner loses a decidedly smaller per cent in the word-word and color-letter material, in original scores (Table IV). For the form-number material all groups lose very nearly the same proportion. The sigma-scaled scores (Table V) show a similar situation although these differences are not as great. There can be no doubt but that in the

TABLE IV

METHOD OF EQUAL AMOUNT LEARNED
Number and per cent of pairs lost in the interval, for entire group and subgroups
(Method of sub-dividing entire group discussed, page 25)
Original Scores

	Number of Subjects	*Number of Pairs Learned*	*Number of Pairs Lost in Interval*		*Per cent of Pairs Lost in Interval*
			Mean	*S.D. of distribution*	
Word-word					
Slow	9	15	5.00	2.54	33.33
Average	41	15	5.39	2.60	35.93
Fast	3	15	2.00	1.63	13.33
Entire Group	53	15	5.13	2.66	34.20
Form-number					
Slow	15	10	4.93	2.29	49.30
Average	34	10	5.12	2.26	51.20
Fast	3	10	5.67	2.06	56.70
Entire Group	52	10	5.10	2.26	51.00
Color-letter					
Slow	14	10	5.28	2.28	52.80
Average	35	10	5.14	2.46	51.40
Fast	3	10	2.67	1.25	26.70
Entire Group	52	10	5.04	2.43	50.40

TABLE V

METHOD OF EQUAL AMOUNT LEARNED
Number and per cent of pairs lost in the interval for the entire group and subgroups
(Method of sub-dividing group on basis of learning discussed, page 25)
Sigma-scaled Scores

	Number of Subjects	*Learning Score*	*Number of Pairs Lost in Interval*		*Per cent of Pairs Lost in Interval*
			Mean	*S.D. of distribution*	
Word-word					
Slow	9	71	20.22	9.80	28.48
Average	38	71	22.13	8.45	31.17
Fast	6	71	12.50	7.85	17.60
Entire Group	53	71	20.72	9.14	29.18
Form-number					
Slow	8	69	19.87	11.23	28.80
Average	41	69	18.46	9.22	26.75
Fast	3	69	21.00	9.42	30.43
Entire Group	52	69	18.83	9.60	27.29
Color-letter					
Slow	10	69	18.80	5.93	27.25
Average	35	69	20.66	10.38	29.94
Fast	7	69	10.43	5.58	15.12
Entire Group	52	69	18.92	9.76	27.42

word-word and color-letter series the fast learner retains a larger per cent than the slow learner in spite of the advantage that the slow learner has from overlearning. In the form-number series the fast and slow learners lose approximately the same amount although the fast learner had learned the material less thoroughly.

Differences in retention are shown in Table VI. Positive differences indicate a greater loss for the slow learner, negative differences a greater loss for the fast learner. The comparison of the groups by pairs shows that the slow learner has the greater loss in about half the comparisons. The significance of these differences was first determined by the usual method of the critical ratio ($D/\sigma_{diff.}$). Since the groups were small, these results were checked by the method of determining significance of the difference between small groups developed by R. A. Fisher (4). The value P indicates the probability that a difference as large as, or larger than, the ones obtained could arise by chance.

By the method of critical ratio the positive differences for the original scores are significant in all cases except the slow and average comparison in the color-letter material. For sigma-scaled scores, positive differences are significant, or almost significant, except for

TABLE VI

METHOD OF EQUAL AMOUNT LEARNED

Reliability of differences between slow, average and fast learners in number of pairs lost during five day interval

Negative quantities indicate that the faster learner lost more in the interval than the slower learner

	Original Scores			*Sigma-scaled Scores*				
	Method of Critical Ratio			*Method of Critical Ratio*			*Fisher's Method*	
	Dif.	$D/\sigma_{dif.}$	*Chances signif.*	*Dif.*	$D/\sigma_{dif.}$	*Chances signif.*	*t*	*P**
Word-word								
Slow-Average	–.39	.41	65	–1.91	.54	71	.5781	.6
Average-Fast	3.39	3.32	100	9.63	2.77	99.74	2.5620	.01
Slow-Fast	3.00	2.36	99.2	7.72	1.69	96	1.5075	.2
Form-number								
Slow-Average	–.19	.27	61	1.41	.33	63	.3727	.7
Average-Fast	–.55	.44	67	–2.54	.45	67	.4389	.7
Slow-Fast	–.74	.56	71	–1.13	.17	57	.1406	.9
Color-letter								
Slow-Average	.14	.19	58	–1.86	.73	77	.5301	.6
Average-Fast	2.47	2.98	99.9	10.23	3.75	100	2.4781	.01
Slow-Fast	2.61	2.78	99.74	8.37	2.97	99.9	2.7584	.01

* P of .05 or less indicates that difference is clearly significant.

the slow-average comparison in the form-number material, when evaluated in terms of either the critical ratio method or Fisher's method. Where the faster learner had a greater loss (negative quantities Table VI) none of the differences are significant by either method. All these results show significantly greater loss during the interval for the slower learner, indicating that the slow learner retains less than the faster learner in spite of the fact that she had overlearned some pairs.

c. *Analysis by comparison of groups of different learning ability in terms of number of trials to relearn the material.*—The average number of trials to learn and to relearn with the standard deviation of the distribution for each type of material for the subdivisions and for the entire group are shown in original scores in Table VII and in sigma scores in Table VIII. A few more trials were necessary to learn the color-letter pairs than the word-word and form-number pairs. This is probably due to the nature of the material. It is almost impossible to find pairs of words between which some sort of connection cannot be made; and this relation though obscure aids in recall. Extraneous relations are much more difficult to find in the color-letter material.

TABLE VII

METHOD OF EQUAL AMOUNT LEARNED
Number of trials to learn and number of trials to relearn each series completely for the entire group and subgroups
(Method of sub-dividing entire group discussed, page 25)
Original Scores

	Number of Subjects	*Number of Trials to Learn*		*Number of Trials to Relearn*	
		Mean	*S.D. of distribution*	*Mean*	*S.D. of distribution*
Word-word					
Slow	9	8.78	1.40	3.00	1.15
Average	41	4.10	1.10	2.27	.50
Fast	3	2.00	0	1.67	.47
Entire Group	53	4.77	2.19	2.36	.73
Form-number					
Slow	15	6.13	.72	2.67	.94
Average	34	3.71	.75	2.53	.74
Fast	3	2.00	0	2.00	0
Entire Group	52	4.31	1.42	2.54	.80
Color-letter					
Slow	14	9.22	1.27	3.14	1.60
Average	35	4.80	1.19	2.66	.92
Fast	3	2.67	.47	2.00	0
Entire Group	52	5.86	2.40	2.74	1.15

The differences between the groups in relearning were found, first in original scores and then in sigma-scaled scores. The group was subdivided on the basis of learning scores in sigma units. Relearning scores in original units were then converted into these sigma-scaled scores. The differences in relearning at different points of the scale could then be expressed in comparable units. This scaling procedure seems justified as we are really measuring the same function, though at different times. It would seems that memory for the same material under different conditions can be measured on the same scale, just as a yardstick is used to measure growth at different age levels.

Comparisons in Table IX show that the slower learner relearns more slowly than the fast learner. The evaluation of these differences by both the critical ratio and Fisher methods gives essentially the same results. The differences are significant for original and sigma-scaled scores except for the slow and average comparison in the form-number and color-letter material. On the whole, the differences show clearly that the fast learner relearns more quickly than the slow learner which may indicate superior retention or may again be more rapid relearning (page 25).

TABLE VIII

METHOD OF EQUAL AMOUNT LEARNED

Number of trials to learn and number of trials to relearn each series completely for entire group and subgroups

(Method of dividing group on basis of learning scores discussed, page 25)

Sigma-scaled Scores ($M = 50$, $\sigma = 10$)

	Number of Subjects	*Number of Trials to Learn*		*Number of Trials to Relearn*	
		Mean	*S.D. of Distribution*	*Mean*	*S.D. of Distribution*
Word-word					
Slow	9	64.78	4.21	41.22	8.15
Average	38	48.13	5.81	37.00	3.47
Fast	6	35.00	0	33.33	3.72
Entire Group	53	50.32	9.82	37.30	5.09
Form-number					
Slow	13	62.00	4.08	37.69	8.58
Average	36	47.27	5.10	37.20	6.74
Fast	3	32.00	0	32.00	0
Entire Group	52	50.04	9.09	37.02	7.17
Color-letter					
Slow	10	64.30	3.66	37.00	8.23
Average	35	49.46	4.72	34.46	7.94
Fast	7	35.86	2.80	29.00	0
Entire Group	52	50.48	9.21	34.21	7.78

The learning and relearning data were further treated by computing (1) number of items learned per trial, (2) number of items relearned per trial, and also (3) number of items saved per trial by the slow, average and fast learners for each type of material in both original and sigma-scaled scores (Tables X and XI). In order better to evaluate these results, the relative efficiency of the three groups of learners was then obtained in the following way. In each of the three pairs of comparisons (slow and average, average and fast, slow and fast learners) accomplishment of the slower of the two groups of learners being compared, in terms of items learned per trial, was expressed as a *percentage* of the items learned per trial by the faster learners. Thus in the word-word series, for example, the slow learners (Table XII) learned at a rate which was only 46.72 per cent as rapid as the average learners; the average learners' rate was 48.80 per cent of the fast learners' rate; the rate of the slow learners was 22.80 per cent of the rate of the fast learners. Similar calculations were made for relearning and saving scores. When the rate of the faster learner is stated as a per cent of the

TABLE IX

METHOD OF EQUAL AMOUNT LEARNED

Reliability of differences between slow, average and fast learners in number of trials needed to relearn for three types of material

Positive differences indicate that slower learner required more trials to relearn

	Original Scores			*Sigma-scaled Scores*				
	Method of Critical Ratio			*Critical Ratio Method of*			*Fisher's Method*	
	Dif.	$D/\sigma_{dif.}$	*Chances signif.*	*Dif.*	$D/\sigma_{dif.}$	*Chances signif.*	*t*	*P**
Word-word								
Slow-Average	.73	1.87	97.00	4.22	1.52	93.0	2.3541	.02
Average-Fast	.60	2.14	98.00	3.67	2.26	98.8	2.3308	.02
Slow-Fast	1.33	2.83	99.74	7.89	2.53	99.4	2.0706	.05
Form-number								
Slow-Average	.14	.52	69.00	.49	.19	58.0	.2036	.8
Average-Fast	.53	4.08	100.00	5.20	3.64	100.0	1.2981	.2
Slow-Fast	.67	2.79	99.74	5.69	2.39	99.2	1.0733	.3
Color-letter								
Slow-Average	.48	1.04	85.0	2.54	.86	80.0	.8903	.4
Average-Fast	.66	4.12	100.0	5.46	4.07	100.0	1.8479	.05
Slow-Fast	1.14	2.65	99.6	8.00	3.08	100.0	2.4167	.02

* P of .05 or less indicates that difference is clearly significant.

TABLE X

METHOD OF EQUAL AMOUNT LEARNED

Comparison of fast, average and slow learners in terms of number of items learned, relearned and saved per trial in method of equal amount learned

Original Scores

	Word-word Series			*Form-number Series*			*Color-letter Series*		
	Items per Trial			*Items per Trial*			*Items per Trial*		
	Learned	*Re-learned*	*Saved*	*Learned*	*Re-learned*	*Saved*	*Learned*	*Re-learned*	*Saved*
Slow.....	1.71	5.00	3.29	1.63	3.74	2.11	1.08	3.18	2.10
Average...	3.66	6.61	2.95	2.70	3.95	1.25	2.08	3.76	1.68
Fast.....	7.50	8.98	1.48	5.00	5.00	0	3.74	5.00	1.26
Entire Group...	3.14	6.38	3.24	2.32	3.94	1.62	1.71	3.65	1.94

TABLE XI

METHOD OF EQUAL AMOUNT LEARNED

Comparison of fast, average and slow learners in terms of number of items learned, relearned and saved per trial in method of equal amount learned

Sigma-scaled Scores

	Word-word Series			*Form-number Series*			*Color-letter Series*		
	Items per Trial			*Items per Trial*			*Items per Trial*		
	Learned	*Re-learned*	*Saved*	*Learned*	*Re-learned*	*Saved*	*Learned*	*Re-learned*	*Saved*
Slow	1.10	1.72	.62	1.11	1.83	.72	1.07	1.86	.79
Average	1.48	1.92	.44	1.46	1.85	.39	1.40	2.00	.60
Fast	2.03	2.13	.10	2.16	2.16	0	1.92	2.38	.46
Entire Group	1.41	1.90	.49	1.38	1.86	.48	1.37	2.02	.65

rate of the slower learner, the greater efficiency of the slower learner is indicated by a minus sign (Tables XII and XIII).

TABLE XII

METHOD OF EQUAL AMOUNT LEARNED

Comparison of efficiency of slow, average and fast learners with items per trial of slower group expressed as a percentage of items per trial of faster group

Negative quantities indicate greater efficiency of slower learner of each pair of comparisons

Original Scores

	Word-word Series			*Form-number Series*			*Color-letter Series*		
	Learn	*Re-learn*	*Saved*	*Learn*	*Re-learn*	*Saved*	*Learn*	*Re-learn*	*Saved*
Slow / Average	46.72	75.64	−89.66	60.37	94.68	−59.24	51.92	84.57	−80.00
Average / Fast	48.80	73.61	−50.10	54.00	79.00		55.61	75.20	−75.00
Slow / Fast	22.80	55.68	−44.98	32.60	74.80		28.88	63.60	−60.00

The faster learners are more efficient in terms of items learned per trial in every case. In relearning, although the faster learner is again more efficient than the slower learner, her superiority is not as great as in learning rate. But the greatest saving was made by the slower learners.

TABLE XIII

METHOD OF EQUAL AMOUNT LEARNED

Comparison of efficiency of slow, average and fast learners in method of equal amount learned. Items per trial of slower group expressed as a percentage of items per trial of faster group

Negative quantities indicate greater efficiency of slower learner in pair compared

Sigma-scaled Scores

	Word-word Series			*Form-number Series*			*Color-letter Series*		
	Learn	*Re-learn*	*Saved*	*Learn*	*Re-learn*	*Saved*	*Learn*	*Re-learn*	*Saved*
Slow / Average	74.32	89.58	−70.97	76.03	98.91	−54.17	76.43	93.00	−75.95
Average / Fast	72.90	90.14	−22.73	67.59	85.65		72.92	84.03	−76.67
Slow / Fast	54.19	80.75	−16.13	51.39	84.72		55.73	78.15	−58.23

The saving scores indicate that the slow learner either because of superior retention ability or of the advantage obtained from overlearning is able to relearn at a much more rapid rate than she learned. The fact that the slow learner acquires the material at a slower rate in the original learning and thus has an opportunity to overlearn, probably explains her more rapid rate of relearning and greater saving. However, not much importance should be attached to this greater saving which is an artifact necessarily arising from the learning situation.

6. *Conclusions*

1. Correlations of the number of trials to learn with (1) the number of pairs retained, and (2) the number of trials to relearn indicate a tendency for the fast learner[1] to be the better retainer. However, the evidence from correlations is not conclusive and the interpretation of these correlations is complicated by the factor of overlearning which is inherent in the method of Equal Amount Learned.

2. Comparison of measures of retention for groups differing in learning ability give the following results:

(*a*) In terms of *number of pairs lost* in the five-day interval, the slow learner loses a larger proportion of what was learned in spite of the advantage of overlearning.

[1] Fast, average and slow learner defined in footnote, page 5.

(*b*) In terms of *number of trials to relearn,* the fast learner relearns more quickly which may indicate better retention. This result is not conclusive as it may indicate fast learning at both times instead of good retention.

(*c*) In terms of *items learned per trial* and *items relearned per trial,* the fast learner is more efficient.

(*d*) In terms of *items saved per trial,* slow learners are more efficient but this result is probably an artifact of overlearning.

CHAPTER III

THE METHOD OF EQUAL OPPORTUNITY TO LEARN

1. *The Method*

The method used in this experiment was that of allowing all of the subjects the *same* time in which to learn the material. The speed of learning was measured by the number of pairs learned in the given time. This method gives the fast learner an advantage, when the amount of material retained is considered as he learns more and so has more to retain. On the other hand, if the amount lost in the interval is considered, he has an opportunity to lose more than the slow learner. In either case, therefore, the measure of retention is affected by the experimental conditions.

2. *Subjects*

The subjects for this experiment were fourth-, fifth- and sixth-grade children in the grammar schools of Arlington and Pleasant Valley. Both towns are suburbs of Poughkeepsie, New York. There were 186 in this group, but final records of only 149 were considered throughout. Some records were incomplete because of absences, and others were omitted because it seemed desirable to drop out scattering cases at the extremes of the age range. The age range of the entire group of 186 was from eight years to fifteen years. The few scores at the extremes were from very slow children in the upper age range or from young advanced pupils in the lower age range. Our study included only the children from nine years, 0 months through thirteen years, eleven months. The correlations of our learning scores (number of pairs recalled immediately) with age are given in Table XIV for the group of 149 cases included in this study. These correlations are very small, so that the factor of age may be considered negligible.

The number of cases in the entire group is less than 149 in some calculations. This happened because a few subjects were included who had complete records except for one series. This incompleteness was due to failure to learn any material or to the fact that the responses given by the subject were not for the right type of material.

There were two reasons for selecting children for this experiment. Children in elementary schools have a wider range of scores on intelligence tests than college students; hence a greater range

TABLE XIV

METHOD OF EQUAL OPPORTUNITY

Correlations of number of pairs learned with age expressed in months. Subjects were children ranging in age from 9 years, 0 months, to 13 years, 11 months

Material	*Number of Subjects*	*Correlations with age*
Word-word	147	$-.03 \pm .06$
Picture-number	149	$-.001 \pm .06$
Color-letter	149	$.05 \pm .06$
Form-word	149	$.13 \pm .05$
Face-name	149	$.04 \pm .06$

of difference in learning and retention scores can be expected. Also paired associates learning tests are more apt to be interesting to children than to adults. This would be particularly true of these children who have not been subjected to as much testing and experimenting as have the children in New York City.

The group upon whom we had complete results included 86 boys and 63 girls. The girls had a slightly smaller age range and on the average were younger. The average age for the boys was 11 years, 4 months with S.D. of 13.3 months; the average age for the girls was 10 years, 10 months with S.D. of 11.3 months.

3. *Material*

Learning material consisted of paired associates in which the second member of the pair was so selected as to be easily written. The material was mounted on white cardboard cards similar to those used in the first experiment. The letters and numbers were black and were two inches high. (Willson's gummed letters.)

Every attempt was made to have the material easy enough for children and at the same time interesting. The following five types of material were selected:

1. Word-word pairs: four letter English words in common usage with no obvious association between members of a pair. Examples are: flag–crab; lake–club.

2. Picture-number pairs: two place numbers and pictures about three inches square in black and white. Examples are: milk bottle–91; bicycle–14; football–48.

3. Color-letter pairs: a three-inch square of color and one letter which was never the first letter of the name of the color. Examples

are: pink–H; orange–B; purple–F. The colors were similar to those used in the earlier experiment with a few additional ones.

4. Form-word pairs: geometrical designs of easily distinguishable shape about three inches square drawn in black and a six-letter English word of concrete meaning. Examples are: a square–letter; a circle–turtle; a triangle–pepper.

5. Face-name pairs: an equal number of boys' and girls' pictures showing head and shoulders and first names which were short and not unusual. The pictures were in black and white about three inches square cut from magazines advertisements. Examples are: a picture of a laughing boy with a football helmet–Bill; smiling baby with light curly hair–Dick; girl with light curly hair wearing glasses–Judy.

Preliminary experimenting was done on a small group to determine the difficulty of the material and the best number of cards to include in a series. Words which were of abstract meaning were found to be rather difficult for the children to learn and hence were changed to more concrete words. In the case of the pictures some were not learned by the preliminary group. These were changed as they were apparently not easily recognized or were unfamiliar. In two cases the names used for the children were changed as they seemed difficult to spell or were unfamiliar.

Twenty pairs of each type of material were finally selected. These were divided into two series of ten pairs each, so that reliability coefficients could be determined.

4. *Procedure*

The experiment was conducted as a group experiment during the regular school hours and in the regular classroom for each grade. This meant that the experimenting was done in six different groups. However, the conditions were fairly constant and the same experimenter served throughout. The teacher was present in the room but took no part in the experiment except to pass and collect papers.

General instructions were first given by the experimenter. The children were assured that the scores they made in this work would not affect their school marks. They were told that children in other grades were learning the same material and were urged to do their best so that their grade would be the highest. They were told that their retention of the material would be tested later. Since they would know this anyway, when the second set of material was presented, it seemed advisable to tell them at the outset, so that their

attitude in this respect would be more nearly constant. This knowledge made the conditions of the experiment more like those of the first experiment (page 22). Although an attempt was made to select familiar words, it was felt that uncertainty in spelling might deter some children from writing responses which were actually recalled. For this reason, the experimenter explained that no credit was to be deducted for spelling and asked the children to write every word they could remember even though they were not sure of the spelling. At the end of the experimental period, the subjects were requested not to tell children in other grades what the material was like which they had seen on the cards.

Each child was provided with five mimeographed sheets on which to write the responses, one sheet for each type of material. There was a space for the child's name and then ten numbers after which the responses were to be written.

Before the actual experiment was started, a sample card with two words was shown. The children were also shown the card as it would be presented for testing, so they would know which word they would be expected to write.

The cards of the word-word series were presented visually one at a time. Each card was exposed for four seconds, the time being regulated by a metronome set at 60. The metronome was started before the experimenting began so that there would be an opportunity for the children to become accustomed to it. The series of ten cards was presented four times. The order of the cards in each presentation was different so that no card would have the continued advantage of primacy or recency; moreover, this procedure served to insure the responses being learned as pairs and not as a list. After the cards had been presented once, the subjects were reminded that they would have to write one member of each pair, and the series was presented again. Before each presentation, the experimenter mentioned the test trial which would be given and before the last presentation told the subjects that it would be the last time they would see both parts of the card.

In testing for immediate memory, the cards were shown with one word concealed by a cover card. The children were asked to write the word that "went with" the one being shown. Six seconds were allowed for response to each card.

The procedure was the same for all cards except the form-word and face-name pairs, which were presented only three times, as preliminary experimentation showed that they were easier to learn.

More time was allowed to write the responses for the longer words and the names. Before a new series was shown a short description of the material on the card was given and the children were told which part they would be asked to write later. The series were learned in the following order: word-word; picture-number; color-letter; form-word; face-name. About fifty minutes were required for the learning period.

Delayed memory was tested after 48 hours. As before, the first part of the card was shown and the children were asked to write what "went with" it. The series were tested in the same order as they had been learned, and the subjects were told which type of material each would be so they would know what they were expected to write. The interval between learning and recall was short since there is little meaning in the material and hence it is difficult to retain. Several intervals were tried in the preliminary experimenting and 48 hours proved to be most satisfactory, as with longer intervals the range of scores was decreased considerably.

Three weeks after the first day of learning, the second set of material was learned. The procedure was the same as it was for the first set except that the materials were reversed so that the order for the second set was face-name; form-word; color-letter; picture-number; word-word. This was done so that whatever practise effect there was from becoming accustomed to the experiment would be equalized for the different types of material when all twenty cards are considered. The word-word pairs were first in the first set and so had the least advantage from practise; they were last in the second series, thus getting all the advantage possible. The effects of fatigue would be similarly equalized but in the reverse way.

In order to give some encouragement and to sustain interest in the second set of material, each grade was told some of their results from the previous experimental period. They were told on which material their grade had the best scores. This was arranged so that each grade was highest or next to the highest in learning or retaining some types of material.

The retention of the second set of material was tested 48 hours after it was learned.

In addition to the number of pairs recalled in immediate and delayed retention, we calculated the difference between the learning score and the retention score after 48 hours. The number of responses lost (forgotten) in the interval by each subject was obtained

for all five types of material. Scores for the two sets of ten cards were combined to give a total score for twenty cards.

There were, therefore, three measures of memory:

(1) *number of pairs recalled immediately* after presentation;

(2) *number of pairs recalled after 48 hours;* and

(3) *number of pairs lost in the 48-hour interval.*

From the original scores for learning and retention, "true" scores were estimated in the following manner. The reliability coefficients were calculated for each type of material from the scores on the two sets of ten cards each. Estimated true scores were then obtained by the formula: $\overline{X}_\infty = r_{11}X_1 - (1-r_{11})\ M$, in which r_{11} is the reliability coefficient and X_1 is the subject's obtained score (12). The scores obtained are free from errors of measurement and correlations computed from them are not subject to the error discussed by Thorndike (31).

From the estimated true scores for immediate recall, a sigma scale was drawn up so that we had scores on a scale of equal units. This is a procedure similar to that used in the method of Equal Amount Learned (page 26). A loss of two points in the *original* scale may not be equivalent at different parts of the scale. But a loss of two units in the *sigma* scale has the same value at different parts of the scale. The estimated true scores for delayed memory were transmuted into sigma units using the sigma scale drawn up from immediate memory scores. This seemed justified on the assumption that the delayed memory scores are really estimates of the same function measured in the initial memory tests.

5. *Results*

a. *Analysis by correlation.*—Reliability coefficients for the five types of material are shown in Table XV. The reliabilities of the learning and retention scores are fairly high considering the length of the series.

Correlations are given in Table XVI between learning and retention scores (original scale) and between learning and loss after 48 hours (original and sigma scales). It may be again noted that the learning and loss correlations (sigma scale) are corrected for errors of measurement (see above) and hence are not subject to the "inflating" effect mentioned on page 13.

It is not easy to interpret the correlations between learning and retention in Table XVI. If the fast learner is the better retainer, we should expect high positive correlation between number of pairs

TABLE XV

METHOD OF EQUAL OPPORTUNITY

Reliability coefficients determined for paired associates material on a group of children

Material	*Learning Scores (Number of pairs recalled immediately)*			*Retention Scores (Number of pairs recalled after 48 hours)*		
	Number of subjects	*Series 1 vs. Series 2 (10 items each)*	*Estimate for series of 20 items*	*Number of subjects*	*Series 1 vs. Series 2 (10 items each)*	*Estimate for series of 20 items*
Word-word	147	.51 ± .04	.68 ± .03	147	.49 ± .04	.66 ± .03
Picture-number	149	.53 ± .04	.69 ± .03	149	.41 ± .04	.58 ± .04
Color-letter	149	.58 ± .04	.74 ± .02	146	.52 ± .04	.68 ± .03
Form-word	148	.64 ± .03	.78 ± .02	147	.53 ± .04	.69 ± .03
Face-name	149	.51 ± .04	.68 ± .03	149	.48 ± .04	.65 ± .03

TABLE XVI

METHOD OF EQUAL OPPORTUNITY

Correlations of number of pairs learned with number of pairs retained after 48 hours and with number of pairs lost in 48 hours. Scores in original and Sigma-scaled units

Material	*Original Scores*			*Sigma Scores*
		(1)	*(2)*	*(3)*
	Number of subjects	*Learning and Retention*	*Learning and Loss*	*Learning and Loss*
Word-word	147	.83 ± .02	.50 ± .04	.16 ± .05
Picture-number	149	.78 ± .02	.69 ± .03	.32 ± .05
Color-letter	146	.81 ± .02	.63 ± .03	.57 ± .04
Form-word	147	.77 ± .02	.19 ± .05	.54 ± .04
Face-name	149	.82 ± .02	.16 ± .05	.55 ± .04

learned and number of pairs retained; high score, high retention; low score, low retention. But if the slow learner is the better retainer, we should expect the correlation between learning and retention to be zero or perhaps slightly negative. This must follow because if the fast learners lose a large number of pairs, their high scores in number of pairs learned will tend to cluster with small number of pairs retained in the correlation table; while retention score of the slow learner (small number of pairs learned), since it cannot exceed the number of pairs learned, will tend to accompany a small number of pairs retained. The correlation will thus tend

to be zero or negative. The correlations in Table XVI, column 1, are all high, and hence in favor of the fast learner, as far as they go. They are not conclusive, however, since in our experimental method the fast learner learns more and hence has a better chance to retain more than the slow learner. Part of the correlation in Table XVI, column 1, is owing no doubt to this factor; but it hardly seems plausible that all of it is.

Consider now the correlations between learning (number of pairs recalled immediately after presentation) and loss (number of pairs lost in 48 hours) presented in Table XVI, columns 2 and 3. If the fast learner who has learned more, loses less than the slow learner in absolute scores, the correlation between learning and loss should be negative or zero. But if the slow learner who has learned less, loses less than the fast learner in absolute score, the correlation should be positive. Errors of measurement would tend to increase this positive correlation (page 13); while the experimental method employed which offers an advantage to the fast learner also makes for positive correlation.

The positive correlations between learning and loss in Table XVI are reduced in three of the five correlations when the errors of measurement are ruled out by using sigma scores which are based upon estimated true scores.[1] If the second factor (advantage of method to fast learner) could also be eliminated it seems possible that the correlations would drop still more. The evidence though not final is again that the fast learner is the better retainer.

b. *Analysis by groups of different learning ability.*—The data were next analyzed by comparing the performance in retention of fast, average and slow learners as was done in the method of Equal Amount Learned. The entire group was subdivided into slow, average and fast learners. The slow group included that part of the distribution from -3 sigma to -1 sigma; the average group that part of the distribution $\pm$ sigma from the mean; the fast group that part of the distribution $+1$ sigma to $+3$ sigma. The means and standard deviations of the distributions of *number of*

[1] An explanation for the rise in the form-word and face-name correlations, when corrected for errors of measurement, can be found by inspecting the correlation tables. The form-word and face-name material was apparently easier to retain, and as a result there is a group of fast learners who lose very little during the interval. This group causes the extremely low correlations in the original scores for the two tests. Sigma scaling increases the losses of the fast group, scattering the fast learners who lose little (in original scores) in such a way that the correlations are raised. Thus the increase in correlations for the form-word and face-name material is attributable to the nature of the material.

pairs learned and *number of pairs lost in the 48 hour interval* for the different types of material are shown in Table XVII for original scores. Table XVIII gives the same data for the estimated true

TABLE XVII

METHOD OF EQUAL OPPORTUNITY

Number of pairs learned, number and proportion of pairs lost in 48 hours Number of cases, mean and standard deviation of distribution for entire group and subdivisions according to learning ability. (See page 42)
Original Scores

	Number of subjects	*Number of Pairs Learned*		*Number of Pairs Lost in Interval*		*Per cent Lost of Pairs Learned*
		Mean	*S.D. of distribution*	*Mean*	*S.D. of distribution*	
Word-word						
Slow	20	4.10	1.76	2.60	1.46	63.41
Average	95	11.26	2.54	5.35	2.12	47.51
Fast	32	17.31	1.07	6.69	2.53	38.65
Entire Group	147	11.61	4.44	5.27	2.45	45.27
Picture-number						
Slow	19	3.26	1.12	1.95	1.05	59.82
Average	99	9.17	2.51	5.02	2.11	54.74
Fast	31	15.90	1.67	7.77	2.70	48.87
Entire Group	149	9.82	4.29	5.20	2.71	52.95
Color-letter						
Slow	24	3.12	.93	1.92	1.08	61.54
Average	93	8.92	2.40	4.85	1.96	54.37
Fast	29	14.93	1.72	6.45	2.53	43.20
Entire Group	146	9.17	4.13	4.68	2.40	51.04
Form-word						
Slow	18	7.50	2.39	3.89	1.49	51.87
Average	94	14.96	2.45	6.19	2.71	41.38
Fast	35	19.52	.50	5.12	3.49	26.23
Entire Group	147	15.13	4.04	5.65	2.91	37.34
Face-name						
Slow	19	7.05	2.31	3.63	1.84	51.49
Average	100	13.99	1.86	4.80	2.33	34.31
Fast	30	18.43	.96	4.27	2.26	23.17
Entire Group	149	14.00	3.65	4.54	2.29	32.43

scores sigma scaled. It is clear that the picture-number and color-letter material was slightly harder than the other types of material, both to learn and retain.

The loss in retention for each group was calculated and the reliability of the differences between groups compared by the critical

TABLE XVIII

METHOD OF EQUAL OPPORTUNITY

Number of pairs learned, number and proportion of pairs lost in 48 hours. Number of cases, mean and standard deviation of distribution for entire group and subdivisions according to learning ability. (See page 42)

Sigma-scaled Scores

	Number of subjects	Number of Pairs Learned		Number of Pairs Lost in Interval		Per cent Lost of Pairs Learned
		Mean	S.D. of distribution	Mean	S.D. of distribution	
Word-word						
Slow	21	34.62	3.77	16.86	6.63	48.70
Average	98	48.14	3.26	17.79	6.65	36.20
Fast	28	63.64	4.05	20.36	5.08	31.99
Entire Group	147	49.83	9.64	18.14	6.48	36.40
Picture-number						
Slow	23	35.09	4.06	17.39	4.65	49.56
Average	106	48.96	5.17	22.35	5.69	42.73
Fast	33	65.13	4.17	24.13	5.82	37.05
Entire Group	163	50.11	9.86	22.17	5.87	42.53
Color-letter						
Slow	24	35.92	3.58	9.25	5.26	25.75
Average	111	50.54	5.04	15.82	4.86	31.32
Fast	31	66.10	5.77	20.90	4.86	31.62
Entire Group	166	50.68	9.56	15.48	5.66	30.70
Form-word						
Slow	26	38.12	4.56	8.96	3.48	27.57
Average	83	48.05	4.18	14.23	4.78	29.47
Fast	38	61.00	4.40	17.68	5.86	28.68
Entire Group	147	48.79	8.81	14.37	5.49	28.86
Face-name						
Slow	20	33.75	4.84	11.25	3.84	33.33
Average	104	48.62	5.71	14.96	5.27	30.15
Fast	23	63.72	4.34	19.83	4.83	31.20
Entire Group	148	48.80	9.87	15.29	5.80	30.92

ratio and by Fisher's method (4). These results appear in Table XIX. The differences show a greater absolute loss for the faster learner than for the slow learner in each pair of comparisons except between the average and fast learners in the form-word and face-name pairs in original scores. The differences are all significant or nearly so by the critical ratio method both for original and sigma-scaled scores. By Fisher's method, the differences are reliable for the sigma-scaled scores except in the comparison of the slow and average learners in the word-word material.

TABLE XIX

METHOD OF EQUAL OPPORTUNITY

Reliability of differences in number of pairs lost in 48-hour interval by slow, average and fast learners
Negative quantities indicate that slower learner lost more in the interval than the faster learner. Positive quantities indicate that faster learner lost more than the slower learner

	Original Scores			*Estimated True Scores on Sigma-scales*				
	Method of Critical Ratio			*Method of Critical Ratio*			*Fisher's Method*	
	Dif.	$D/\sigma_{dif.}$	*Chances signif.*	*Dif.*	$D/\sigma_{dif.}$	*Chances signif.*	*t*	*P**
Word-word								
Average-Slow	2.75	6.88	100	.93	.58	73	.5774	.6
Fast-Average	1.34	2.68	99.7	2.57	2.20	98.6	1.8783	.05
Fast-Slow	4.09	7.30	100	3.50	2.01	98	2.0456	.05
Picture-number								
Average-Slow	3.07	9.59	100	3.96	3.54	100	3.0814	less than .01
Fast-Average	2.75	5.29	100	2.78	2.09	98	2.0832	.05
Fast-Slow	5.82	10.78	100	6.74	4.35	100	4.2375	less than .01
Color-letter								
Average-Slow	2.93	9.77	100	6.58	8.22	100	6.2480	less than .01
Fast-Average	1.60	3.14	100	5.07	4.37	100	4.2951	less than .01
Fast-Slow	4.53	8.71	100	11.65	9.40	100	9.4135	less than .01
Form-word								
Average-Slow	2.30	5.11	100	4.27	4.96	100	4.1830	less than .01
Fast-Average	−1.07	1.65	94	3.45	3.19	100	3.4170	less than .01
Fast-Slow	1.23	1.78	96	7.72	6.60	100	5.9343	less than .01
Face-name								
Average-Slow	1.17	2.44	99.2	3.71	3.64	100	2.9520	less than .01
Fast-Average	− .53	1.13	87	4.92	4.39	100	4.2206	less than .01
Fast-Slow	.64	1.08	86	8.63	6.54	100	6.2271	less than .01

* P of .05 or less is clearly significant.

If we consider the *proportion* of pairs lost (Tables XVII and XVIII) instead of the loss in *absolute* scores, we find that in original scores the *slower learner* loses a *larger proportion* of what he learned than the fast learner. When the data are sigma-scaled, the proportion lost is larger for the slow learner than for the fast learner in the word-word and picture-number material. For the other three types of material, all groups lose about the same proportion. Although the proportions are not figured from the same learning score for each group and hence are not strictly comparable, they are important in evaluating the results. The fast learner loses more in absolute units; but in relation to the amount he has learned his loss is no greater and in some cases is less than the loss of the slow learner.

6. *Conclusions*

1. Correlations of *number of pairs learned* and *number of pairs retained* after a 48 hour interval indicate that the fast learner[2] is the better retainer. Correlations are not conclusive evidence, however, as the fast learner learns more pairs in a given time and thus has an advantage in retention.

2. The correlation of *number of pairs recalled immediately* and the *number of pairs lost* in the 48 hour interval show that the fast learner loses more than the slow learner. Again the correlations are not conclusive as the fast learner learns more pairs and thus has an opportunity to lose more.

3. A comparison of retention scores (number of pairs lost in 48 hour interval) when the group is subdivided according to ability to learn, shows that:

a. In original scores, the fast learner loses more in *absolute* units during the interval than the slow learner except in two instances. In relation to the number of pairs learned the *fast* learner loses 12 to 28% *less* than the slow learner.

b. In sigma-scaled units, the *absolute* losses are also greater for the fast learner. Again in *proportion* to the amount learned the *fast* learner *loses less.* In the word-word and picture-number pairs there is about 10% smaller *loss* for the *fast* learner than for the slow learner. In the other three tests the proportion lost for all groups is very nearly equal.

---

[2] Fast, average and slow learner defined in footnote, page 5.

CHAPTER IV

METHOD OF ADJUSTED LEARNING

1. *The Method*

We have already pointed out (pages 5 and 12) that the method of Equal Amount Learned and the method of Equal Opportunity To Learn have inherent difficulties which make it almost impossible to give a categorical answer to the question, "Is the fast learner the better retainer?" The first method favors the slow learner, the second favors the fast learner. In the method of Adjusted Learning, the disadvantages of these two methods are in part eliminated. In learning paired associates, a pair is removed from the series as soon as the subject is able to give the correct response, thus obviating overlearning. The fast learner has no distinct advantage as each subject learns approximately the same amount of material and up to the same point. This feature puts the fast and slow learner on an equal basis and favors neither group.

2. *Subjects*

From the group tested by the method of Equal Opportunity To Learn, children of varying memory ability were selected according to their performance on the material of this previous experiment. Twenty-five children in all were drawn pro rata from the entire group, so that they would approximate the proportions of the normal curve. The scores on the picture-number material which would mark the sigma divisions were calculated and children who had scores within given limits were selected for this experiment. More than twenty-five children were actually drawn and tested but due to absences and interruptions of various kinds during the learning, some of the cases had to be discarded. The final group upon which calculations were made contained twenty-five cases. The number of children selected from different parts of the distribution for ability in learning picture-number material is shown in the following table.

From -2σ to lower end	1
Between -1 and -1.99σ	6
At the mean	11
Between $+1\sigma$ and $+1.99\sigma$	6
From $+2\sigma$ to upper end	1
	25

3. *Material*

The picture-number material gave the best distribution from which to select a group which would approximate a normal distribution. It was also possible to obtain additional material of this type without duplication of the series used in the other experimenting. Hence only one type of material was selected for this experiment. A series of 20 cards was made, similar to those for the method of Equal Opportunity, but none of the pictures or numbers were the same as those used in that experiment.

4. *Procedure*

The children were tested individually during the regular school hours. Administration of the tests was carried out by the experimenter who had conducted the previous experiments. All the children were told that they had been selected to learn this material because they had done so well on the cards learned by their grade earlier. They were assured that their scores would not affect their school marks. The experimenter urged them to do their best and told them that if they did well it would not be necessary for them to learn all the cards in the set. They were also told that they would be tested later to find out how much they remembered.

The cards were shown one at a time for four seconds each, the time being regulated by a metronome set at 60. After the entire series had been presented, half of each card was shown and the child was asked to write the number that "went with" the picture. The responses were checked immediately by the experimenter. Any cards to which the correct response had been given were removed from the series which was then presented again. The pairs learned on the second and each succeeding trial were removed as they were learned. This procedure was continued until the child had given the correct response to about ten cards, which was the average number learned in the previous experiment (page 43). The number of trials to attain ten or as near as possible to ten responses was the measure of speed of learning.

This procedure allowed no opportunity to overlearn any pair. The child was told that the cards to which he had given the right response had been removed before the remaining cards were shown again.

After 48 hours retention was tested. Only those cards to which the child had given the correct response during the learning period were shown to him in the retest. The retention of the material was

tested, first, by showing *only* the picture and having the child write the number that "went with" it. The cards were shown then so that the child could see both associates and hence relearn the material. The cards, to which the correct response was given, were not removed this time but the series of cards which had been learned in the original testing was repeatedly presented and tested until all responses were correct. This offers an opportunity to overlearn just as does the method of Equal Amount Learned but overlearning at this time would not affect the results as retention was not tested again.

5. *Results*

The learning scores obtained were the number of trials to learn approximately ten responses. This could not be absolutely controlled; but since the range of scores was from 9 to 11, the average being 9.88 with S.D. = .65, the group was very homogeneous in amount of material learned originally. The retention scores were (1) *the number of pairs recalled when tested after the 48 hour interval;* and (2) *the number of trials to relearn.* Since all the subjects had learned so nearly the same number of pairs, it was possible to use the proportion retained, as the average could be used as the base for all subjects. The results for each subject are shown in Table XX. The per cent retained is given first as figured on the basis of the average number of pairs learned (9.88). In parentheses is the per cent retained of the number of pairs *actually learned* by each child. The figures differ very little, of course, as they were computed on practically the same base and the first ones have the advantage of being figured from the same point.

The two cases at ± 2 sigma were combined with the ± 1 sigma groups, to give three groups differentiated on the basis of ability to learn. The slow learners range from the lowest score to -1 sigma; the average from -1 sigma to $+1$ sigma; the fast group from $+1$ sigma to the highest score. The average learning, retention and relearning scores for the three groups are given in Table XXI.

The reliability of the differences among the different groups in retention scores (Table XXII) was calculated by the method of critical ratio and by Fisher's method (4). Whichever measure of retention we employ, we find the same results. There is a reliable difference between the slow and average learner and between the slow and fast learner, the faster learner consistently having the better retention. The differences between the average and fast learner

TABLE XX

METHOD OF ADJUSTED LEARNING

Individual learning and retention scores of 25 children*
Average number of trials to learn = 9.88, σ = .65

Group	Learning			Retention			Relearning
	Subject Number	Number Trials	Number Pairs	Number Pairs	% of Avg.	% of Actual	Number Trials
-2σ	1	9	9	1	10.12	(11.10)	3
-1σ	2	5	11	2	20.24	(18.20)	4
	3	5	11	2	20.24	(18.20)	3
	4	5	10	1	10.12	(10.00)	5
	5	5	11	3	30.36	(27.30)	2
	6	6	10	0	0	(0)	4
	7	5	11	3	30.36	(27.30)	3
Average	8	4	10	1	10.12	(10.00)	2
	9	4	9	3	30.36	(33.33)	2
	10	4	10	4	40.48	(40.00)	3
	11	3	9	3	30.26	(33.33)	3
	12	3	9	4	40.48	(44.40)	2
	13	4	9	0	0	(0)	4
	14	4	10	4	40.48	(40.00)	2
	15	4	9	2	20.24	(22.20)	2
	16	4	10	6	60.72	(60.00)	4
	17	4	10	1	10.12	(10.00)	3
	18	3	10	6	60.72	(60.00)	1
1σ	19	3	10	3	30.36	(33.33)	1
	20	3	10	7	70.84	(70.00)	1
	21	3	9	2	20.24	(22.20)	3
	22	3	10	2	20.24	(20.00)	4
	23	3	10	2	20.24	(20.00)	2
	24	3	10	4	40.48	(40.00)	3
2σ	25	2	10	7	70.84	(70.00)	1

* Group of 25 children selected pro rata from entire distribution for method of Equal Opportunity To Learn. See page 47.

are not reliable either by Fisher's method or the method of critical ratio (Table XXII).

This experiment substantiates our earlier tentative conclusions. The slow learner retains less than the average or fast learner whether the measure of retention is (1) number of pairs retained; (2) proportion retained; or (3) number of trials to relearn. The slow learner when given sufficient time to learn the *same amount* as the fast learner, but not allowed to *overlearn* the material, is not able to retain as much as the fast learner. Apparently, the advantage which the slow learner often seems to have comes entirely from the fact that through longer and more assiduous application, he learns

TABLE XXI

METHOD OF ADJUSTED LEARNING

Average learning, retention and relearning scores for slow, average and fast learners

	Slow		*Average*		*Fast*	
	Mean	σ	*Mean*	σ	*Mean*	σ
Learning						
Number of trials	5.71	1.38	3.73	.44	2.86	.35
Number of pairs	10.43	.73	9.54	.50	9.86	.35
Retention						
Number of pairs	1.71	1.03	3.09	1.88	3.86	2.10
Per cent of average learned by group	17.35	10.42	31.27	19.03	39.03	21.25
Relearning						
Number of trials	3.43	.90	2.54	.88	2.14	1.12

TABLE XXII

METHOD OF ADJUSTING LEARNING

Reliability of differences in retention for slow, average and fast learners
Retention measured in (1) number of pairs retained, (2) percentage retained of average numbers of pairs learned and (3) number of trials to relearn
Negative quantities indicate that slower learner has larger score.
Positive quantities indicate that faster learner has larger score.

	Difference	*Method of Critical Ratio*		*Fisher's Method*	
		$D/\sigma_{diff.}$	*Chances signif.*	*t*	*P**
(1) Number of pairs retained					
Average-slow learners	1.38	2.00	98	1.6804	.1
Fast-average	.77	.78	78	.7626	.5
Fast-slow	2.15	2.42	99.2	2.2597	.05
(2) Percentage retained of average number of pairs learned					
Average-slow	13.93	2.00	98	1.6754	.1
Fast-average	7.75	.78	78	.7597	.5
Fast-slow	21.68	2.42	99.2	2.2446	.05
(3) Number of trials to relearn					
Average-slow	− .88	2.05	98	1.9251	.05
Fast-average	− .41	.84	80	.8073	.4
Fast-slow	−1.29	2.39	99.2	2.1939	.05

* P of .05 or less is clearly significant.

at least parts of the material to a greater degree than the fast learner. He, therefore, has the advantage in retention and hence saves more in relearning.

There seems to be much less difference in retention between the average learner and the fast learner than between the slow and fast learner or slow and average learner. The tendency, however, is decidedly toward better retention by the faster learner.

It is probable that intelligence determines in some degree the speed of learning and degree of retention. We were able to test this hypothesis for a part of our group. Intelligence quotients from Illinois Intelligence Test were available for 53 of the children who served as subjects in the experiment with the method of Equal Opportunity To Learn. These I.Q.'s were correlated with the number of pairs learned of each type of material (page 43). The correlations are given in Table XXIII. The average correlation of .22

TABLE XXIII

NUMBER OF PAIRS RECALLED IMMEDIATELY IN METHOD OF EQUAL OPPORTUNITY TO LEARN CORRELATED WITH INTELLIGENCE QUOTIENTS

Material	*Number of Subjects*	*Correlations*
Word-word	53	.36 ± .01
Picture-number	53	.08 ± .09
Color-letter	53	.10 ± .09
Form-word	53	.33 ± .08
Face-name	53	.25 ± .09

indicates a positive relation between speed of learning and intelligence but the relation is not high. Other investigators have found a low positive correlation between quickness and intelligence (35) and also between capacity to learn and intelligence (14).

SUMMARY AND CONCLUSIONS FROM CHAPTERS II, III, AND IV

1. The results from the methods of Equal Amount Learned and Equal Opportunity To Learn are affected by the conditions inherent in the methods: Equal Amount Learned by the factor of overlearning which favors the slow learner[1]; and Equal Opportunity by the advantage to the fast learner of learning more pairs in a constant time. The method of Adjusted Learning avoids both of these difficulties. The following conclusions are restricted to learning and retention of visually presented material which is not meaningful.

2. Results from the method of Equal Amount Learned are as follows:

a. Correlations of number of trials to learn and number of trials to relearn, although small, are all positive, showing that the fast learner is the better relearner and hence may have better retention.

b. Correlations of number of trials to learn with number of pairs retained are small, unreliable and negative, but, considering the experimental conditions, give slight evidence for the conclusion that the fast learner is the better retainer.

c. Comparisons of retention of the subdivisions differentiated on the basis of learning ability yield the following results:

(1) The number of trials to relearn is smaller for the fast learner than for the slow learner.

(2) Items learned per trial and items relearned per trial indicate that the fast learner is more efficient.

(3) In terms of absolute number of pairs lost in the five-day interval and also the proportion of pairs lost, the slow learner loses significantly more than the fast learner although the slow learner would be expected to have an advantage from overlearning parts of the material. This is true for both original and sigma scaled scores.

3. With the method of Equal Opportunity To Learn, the results show:

a. Correlations of the number of pairs learned with the number of pairs lost in the 48 hours interval indicate that the fast learner loses more than the slow learner, but since he has learned more, this is not conclusive.

---

[1] Fast, average and slow learner defined in footnote on page 5.

b. Correlations of number of pairs learned with number of pairs retained after 48 hours show that the fast learner retains more, but this again is difficult to interpret because of the experimental conditions.

c. In original and sigma-scaled scores the subdivision which contains the fast learners loses more in absolute score during the interval than the slow learner who, however, has learned less.

d. In relation to the amount he has learned, the fast learner loses from 10 to 25 per cent less than the slow learner in original scores.

e. In the sigma-scaled scores, the fast learner loses 12 and 17 per cent less than the slow learner in two cases and in the other three cases about the same proportion is lost by both groups.

4. The method of Adjusted Learning in which all subjects learn the same amount of material and no one has an opportunity to overlearn, gives clear evidence that the fast learner retains more of the material for the same length of time in terms of (1) number of pairs retained, (2) proportion of pairs retained, and (3) number of trials needed to relearn.

5. We conclude, therefore, that the three methods do not contradict each other and indicate clearly that the fast learner is the better retainer.

BIBLIOGRAPHY

1. Boswell, F. P., and Foster, W. S. On memorizing with the intention permanently to retain. *Amer. J. Psychol.*, 1916, 27, 420–426.
2. Brown, W. Effects of interval on recall. *J. Exper. Psychol.*, 1924, 7, 469–474.
3. Drake, M. J. The correlation between learning and retention capacity. M.A. thesis, Columbia University, 1926. (Unpublished.)
4. Fisher, R. A. Statistical methods for research workers. London, 1932.
5. Gates, A. I. Correlations of immediate and delayed recall. *J. Ed. Psychol.*, 1918, 9, 489–496.
6. Gleason, J. M. Learning. *Psychol. Bull.*, 1919, 16, 339–344.
7. Gleason, J. M. Memory and learning. *Psychol. Bull.*, 1920, 17, 256–259.
8. Gordon, K. Class results with spaced and unspaced memorizing. *J. Exper. Psychol.*, 1925, 8, 337–343.
9. Hartshorne, H., and May, M. A. Studies in the nature of character. I. Studies in deceit. New York, 1928.
10. Henderson, E. N. A Study of memory for connected trains of thought. *Psychol. Mono.*, 1903, 5, No. 23, pp. 94.
11. Henmon, V. A. C. The relation between learning and retention and amount to be learned. *J. Exper. Psychol.*, 1917, 2, 476–484.
12. Kelley, T. L. Statistical methods. New York, 1923.
13. Luh, C. W. The conditions of retention. *Psychol. Mono.*, 1922, 31, No. 142, pp. 87.
14. Lyon, D. O. The relation of quickness of learning to retentiveness. *Arch. Psychol.*, 1916, 5, No. 34, pp. 60.
15. McGeoch, J. A. Memory. *Psychol. Bull.*, 1928, 25, 513–549.
16. McGeoch, J. A. Memory. *Psychol. Bull.*, 1930, 27, 514–563.
17. McGeoch, J. A. The psychology of human learnings: a bibliography. *Psychol. Bull.*, 1933, 30, 1–62.
18. McGeoch, J. A. Learning and retention of verbal material. *Psychol. Bull.*, 1934, 31, 381–407.
19. Myers, G. S. Some correlations between learning and recall. *J. Ed. Psychol.*, 1916, 7, 546–547.
20. Norsworthy, N. Acquisition as related to retention. *J. Ed. Psychol.*, 1912, 3, 214–218.
21. Ogden, R. M. Untersuchungen über den einfluss der geschwindigkeit des lauten lesens auf das erlernen und behalten von sinnlosen und sinnvollen stoffen. *Arch. ges. Psychol.*, 1904, 2, 93–189.
22. Peterson, H. A. A class experiment on individual differences in memory. *J. Ed. Psychol.*, 1925, 16, 247–250.
23. Peterson, J. The effect of attitude on immediate and delayed reproduction: a class experiment. *J. Ed. Psychol.*, 1916, 7, 523–532.
24. Pyle, W. H. Retention as related to repetition. *J. Ed. Psychol.*, 1911, 2, 311–321.
25. Pyle, W. H. Standards of mental efficiency. *J. Ed. Psychol.*, 1913, 4, 61–70.
26. Smith, M., and McDougall, W. Some experiments in learning and retention. *Brit. J. Psychol.*, 1919–20, 10, 199–209.
27. Stump, N. F. A class-room experiment in logical learning. *J. Appl. Psychol.*, 1927, 11, 117–126.
28. Syrkin, M. La question de la "convergence" ou de la "divergence" sous l'aspect de la variabilité fluctuante. *Revue Science du Travail.*, 1930, 2, Nos. 3 and 4, 353–364.
29. Thorndike, E. L. Memory for paired associates. *Psychol. Rev.*, 1908, 15, 122–138.
30. Thorndike, E. L. The relation between memory for words and memory for numbers, and the relation between memory over short and memory over long interval. *Amer. J. Psychol.*, 1910, 21, 487–488.

31. Thorndike, E. L. The influence of the chance imperfections of measures upon the relation of initial score to gain or loss. *J. Exper. Psychol.*, 1924, 7, 225–232.
32. Vlaïcou, O. Capacité d'appréhension; rapidité d'acquisition et puissance de rétention de souvenirs bruts. Recherches de corrélation. *L'Année Psychol.*, 1914–19, 21, 171–189.
33. Whitehead, L. G. A study of visual and aural memory processes. *Psychol. Rev.*, 1896, 3, 258–269.
34. Woodworth, R. S. A contribution to the question of "Quick learning, quick forgetting." *Psychol. Bull.*, 1914, 11, 58–59.
35. Woodworth, R. S. Psychology. First revised edition. New York, 1929.

List of numbers, continued from inside front cover

115. Factors Affecting the Galvanic Reflex: R. C. DAVIS. $1.00.
116. Infant's Feeding Reactions During the First Six Months: R. RIPIN. 80c.
117. Measurement of Mental Deterioration: H. BABCOCK. $1.25.
118. Phenomenon of Postural Persistence: L. S. SELLING. $1.00.
119. American Council on Education Rating Scale: F. F. BRADSHAW. $1.00.
120. Group Factor in Immediate Memory: A. ANASTASI. $1.00.
121. Individual Differences in the Sense of Humor and Temperamental Differences: P. KAMBOUROPOULOU. $1.00.
122. Suggestibility in Normal and Hypnotic States: G. W. WILLIAMS. $1.00.
123. Analytical Study of the Conditioned Knee-Jerk: G. R. WENDT. $1.25.
124. Race Differences in Numerical and Verbal Abilities: J. DUNLAP. $1.25.
125. Errors of Measurement and Correlation: E. E. CURETON. $1.25.
126. Experience Factors, Test and Efficiency of Women Office Workers: N. BIRD. $1.00.
127. Delayed Reactions of Infants: C. N. ALLEN. 80c.
128. Factors Measured by the Thorndike Intelligence Examination: J. G. PEATMAN. $1.00.
129. Educational Success and Failure in Supernormal Children: J. REGENSBURG. $1.75.
130. Effect of Practice on Visual Perception of Form: J. P. SEWARD. $1.00.
131. Relation to College Grades of Factors other than Intelligence: D. HARRIS. 80c.
132. Psychological Differences Between "Racial" and National Groups: O. KLINEBERG. $1.00.
133. Emotional Diff. of Delinquent and Non-Delinquent Girls: A. COURTHIAL. $1.25.
134. Learning and Retention of Pleasant and Unpleasant Activities: H. CASON. $1.25.
135. Investigation of Brightness Constancy: R. B. MACLEOD. $1.25.
136. The Rorschach Test Applied to Feeble-Minded Group: S. J. BECK. $1.00.
137. Retention after Intervals of Sleep and of Waking: E. B. VAN ORMER. $1.00.
138. Stimulus Temperature and Thermal Sensation: F. HEISER. $1.00.
139. Energy Cost Measurements on Curve of Work: H. J. SCHUBERT. $1.00.
140. Technique for the Measurements of Attitudes: R. LIKERT. 80c.
141. Speed Factor in Mental Tests: P. H. DUBOIS. 80c.
142. Further Studies on the Memory Factor: A. ANASTASI. $1.00.
143. An Experimental Study on Variability of Learning: S. E. ASCH. $1.00.
144. Inventory for Measurement of Inferiority Feelings. R. B. SMITH. $1.50.
145. The Psychological Effects of Oxygen Deprivation: R. A. MACFARLAND. $1.50.
146. Relation of Subliminal to Supraliminal Learning: O. A. SIMLEY. 80c.
147. Effects of Noise upon Certain Psychological Processes: F. L. HARMON. $1.25.
148. Conditioned Responses in Children: G. S. RAZRAN. $1.50.
149. Resemblance of Parents and Children in Intelligence: M. C. OUTHIT. $1.00.
150. Influence of Oral Propaganda Material upon Attitudes: K-C. CHEN. 80c.
151. Negative or Withdrawal Attitude: H. PALLISTER. 80c.
152. Judgment in Absolute Units as a Psychophysical Method: J. BRESSLER. $1.00.
153. Visual Illusions in the Chick: C. N. WINSLOW. $1.25.
154. Measuring Teaching Efficiency Among College Instructors: G. W. HARTMANN. 80c.
155. Psychogalvanic Responses in Arithmetical Work: R. SEARS. $1.00.
156. Group Factors in Mental Tests: M. SMITH. $1.00.
157. . . . Brightness Discrimination Habit in the Chick: A. B. WOOD. 80c.
158. Accuracy of perception of visual musical stimuli: A. ROE. $1.00.
159. Effect of Practice Upon Individual Differences: R. E. PERL. $1.00.
160. Antagonistic Muscle Action During the Initiatory Stages: D. J. WILSON. $1.00.
161. Verbal, Numerical and Spatial Abilities of Young Children: B. SCHILLER. $1.00.
162. Organization of Memory in Young Children: A. I. BRYAN. $1.00.
163. Self-Estimates of Improvement in Repeated Tasks: N. KNEELAND. $1.25.
164. Biochemical Study of the Metabolism of Mental Work: H. GOLDSTEIN. $1.00.
165. Attitudes and Unemployment: O. M. HALL. $1.00.
166. Change of Socio-Economic Attitudes under Motion Picture Propaganda: S. P. ROSENTHAL. 80c.
167. Methodology of the Digit-Span Test: J. G. PEATMAN & N. M. LOCKE. 80c.
168. Effect of Repetition on Reactions to Electric Shock: J. & G. SEWARD. $1.50.
169. Experimental Comparison of the Speech, the Radio, and the Printed Page . . . : W. H. WILKE. 80c.
170. The Psychophysical Measurement of Visual Sensitivity: F. C. THORNE. $1.00.
171. The Psychological Analysis of Fashion Motivation: E. D. BARR. $1.25.
172. The Relation between Basal Metabolism and Mental Speed: J. STEINBERG. 80c.
173. Written Composition & Characteristics of Personality: ALLPORT, WALKER & LATHERS. $1.25.
174. Block Building Activities of Young Children: F. M. GUANELLA. $1.25.
175. Goodenough Drawings in Relation to Delinquency . . . : W. E. HINRICHS. $1.25.
176. Age Factor in Mental Organization: H. E. GARRETT, A. I. BRYAN & R. E. PERL. 80c.
177. Race Differences in Mental and Physical Traits: R. N. FRANZBLAU. 80c.
178. Creative Thought in Poets: C. PATRICK. $1.00.
179. Photometric Study of the Perception of Object Color: R. H. HENNEMAN. $1.25.
180. The Spread of the Influence of Reward to Bonds Remote in Sequence and Time: H. BRANDT. 80c.
181. Confirmation and Information in Rewards and Punishments: J. EISENSON. 80c.
182. Auditory Threshold in Reverie: M. R. BARTLETT. 80c.
183. Factors Related to Muscular Tension: E. H. HENLEY. 80c.
184. Effect of Context upon Perceptual Differentiation: J. P. FOLEY. $1.00.
185. Study of . . . Differences in Criminal Tendency: E. H. STOFFLET. $1.00.
186. Individual Differences in Work Curves: E. S. MARKS. $1.00.
187. Study of Some Social Factors in Perception: M. SHERIF. $1.00.
188. Mental Efficiency in Senescence: J. G. GILBERT. $1.00.
189. Child's Report of Psychological Factors in the Family: R. S. HAYWARD. $1.25.
190. The Interpretation of Questionnaire Items: A. L. BENTON. 80c.
191. Conditioned Responses: G. H. S. RAZRAN. $1.50.
192. Experimental Study of the Day and Night Motility: J. D. PAGE. 80c.
193. Color Constancy in the Rhesus Monkey and in Man: N. M. LOCKE. 80c.
194. Development of Attitude Toward the Negro: E. L. HOROWITZ. 80c.
195. Change in Mental Organization: S. E. ASCH. ~~$1.00.~~ 80
196. Experience in Perceiving Verbal and Geometric Contexts: J. H. SANDERS. $1.00.
197. Difficulty of Mental Tests on Patterns of Mental Organization: M. HERTZMAN. $1.00.
198. Learning and Retention: A. L. GILLETTE. $1.00.

AMERICAN PSYCHOLOGICAL PERIODICALS

AMERICAN JOURNAL OF PSYCHOLOGY—Ithaca, N. Y.; Cornell University.
Subscription $6.50. 624 pages annually. Edited by M. L. Washburn, K. M. Dallenbach, Madison Bentley, and E. G. Boring. Quarterly. General and experimental psychology. Founded 1887.

JOURNAL OF GENETIC PSYCHOLOGY—Worcester, Mass.; Clark University Press.
Subscription $14.00 per yr.; $7.00 per vol. 1,000 pages ann. (2 vols.) Edited by Carl Murchison. Quarterly. Child behavior, animal behavior, and comparative psychology. Founded 1891.

PSYCHOLOGICAL REVIEW—Princeton, N. J.; Psychological Review Company.
Subscription $5.50. 540 pages annually. Edited by Herbert S. Langfeld. Bi-monthly. General psychology. Founded 1894.

PSYCHOLOGICAL MONOGRAPHS—Princeton, N. J.; Psychological Review Company.
Subscription $6.00 per vol. 500 pages. Edited by Joseph Peterson. Without fixed dates, each issue one or more researches. Founded 1895.

PSYCHOLOGICAL INDEX—Princeton, N. J.; Psychological Review Company.
Subscription $4.00. 400–500 pages. Edited by Walter S. Hunter and R. R. Willoughby. An annual bibliography of psychological literature. Founded 1895.

PSYCHOLOGICAL BULLETIN—Princeton, N. J.; Psychological Review Company.
Subscription $6.00. 720 pages annually. Edited by John A. McGeoch. Monthly (10 numbers). Psychological literature. Founded 1904.

ARCHIVES OF PSYCHOLOGY—New York, N. Y.; Columbia University.
Subscriptions $6.00. 500 pages per volume. Edited by R. S. Woodworth. Without fixed dates, each number a single experimental study. Founded 1906.

JOURNAL OF ABNORMAL AND SOCIAL PSYCHOLOGY—Eno Hall, Princeton, N. J.; American Psychological Association.
Subscription $5.00. 448 pages annually. Edited by Henry T. Moore. Quarterly. Abnormal and social. Founded 1906.

PSYCHOLOGICAL CLINIC—Philadelphia, Pa.; Psychological Clinic Press.
Subscription $3.00. 288 pages. Edited by Lightner Witmer. Without fixed dates. (Quarterly). Orthogenics, psychology, hygiene. Founded 1907.

JOURNAL OF EDUCATIONAL PSYCHOLOGY—Baltimore; Warwick & York.
Subscription $6.00. 720 pages. Monthly except June to August. Edited by J. W. Dunlap, P. M. Symonds and H. E. Jones. Founded 1910.

PSYCHOANALYTIC REVIEW—Washington, D. C.; 3617 10th St., N. W.
Subscription $6.00. 500 pages annually. Edited by W. A. White and S. E. Jelliffe. Quarterly. Psychoanalysis. Founded 1913.

JOURNAL OF EXPERIMENTAL PSYCHOLOGY—Princeton, N. J.; Psychological Review Company.
Subscription $7.00. 900 pages annually. Experimental. Bimonthly. Edited by S. W. Fernberger. Founded 1916.

JOURNAL OF APPLIED PSYCHOLOGY—Indianapolis; C. E. Pauley & Co.
Subscription $5.50. 600 pages annually. Edited by James P. Porter, Ohio University. Anthens, Ohio. Bi-monthly. Founded 1917.

JOURNAL OF COMPARATIVE PSYCHOLOGY—Baltimore, Md.; Williams & Wilkins Company.
Subscription $5.00 per volume of 450 pages. Ed. by Knight Dunlap and Robert M. Yerkes. Two volumes a year. Founded 1921.

COMPARATIVE PSYCHOLOGY MONOGRAPHS—Baltimore, Md.; The Johns Hopkins Press.
Subscription $5.00. 400 pages per volume. Knight Dunlap, Managing Editor. Published without fixed dates, each number a single research. Founded 1922.

GENETIC PSYCHOLOGY MONOGRAPHS—Worcester, Mass.; Clark University Press.
Subscription $7.00 per vol. Bi-monthly, one volume per year. Edited by Carl Murchison. Each number one complete research. Child behavior, animal behavior, and comparative psychology. Founded 1925.

PSYCHOLOGICAL ABSTRACTS—Eno Hall, Princeton, N. J.; American Psychological Association.
Subscription $6.00. 700 pages ann. Edited by Walter S. Hunter and R. R. Willoughby. Monthly. Abstracts of psychological literature. Founded 1927.

JOURNAL OF GENERAL PSYCHOLOGY—Worcester, Mass.; Clark University Press.
Subscription $14.00 per yr.; $7.00 per vol. 1,000 pages ann. (2 vols.) Edited by Carl Murchison. Quarterly. Experimental, theoretical, clinical, and historical psychology. Founded 1927.

JOURNAL OF SOCIAL PSYCHOLOGY—Worcester, Mass.; Clark University Press.
Subscription $7.00. 500 pages annually. Edited by John Dewey and Carl Murchison. Quarterly. Political, racial, and differential psychology. Founded 1929.